DEPARTMENT OF MINING ENGINEERING
Library Number: 1326
Return this book to
Cupboard: K
Shelf: 23
All books are to be signed for in the loan book when borrowed, and when returned.
Books must be returned within One Week, unless special permission is given for a longer loan.

~~chem & phys~~

THE JOURNAL

OF THE

CHEMICAL, METALLURGICAL & MINING SOCIETY

OF SOUTH AFRICA.

VOLUME XVII. — 18

JULY, 1916—JUNE, 1917. — June 1917

157850
18/12/20

JOHANNESBURG:
Published by the Society: Old Municipal Buildings, De Villiers Street.

TN
1
S66
v.17-18

CONTENTS OF VOLUME XVII.

	Page.
Papers and Notes Read before the Society	v.
Officers and Council of the Society ...	vii.
Journal No. 1.—July, 1916	1
,, ,, 2.—August, ,, ...	9
,, ,, 3.—September, ,, ...	25
,, ,, 4.—October, ,, ...	57
,, ,, 5.—November, ,, ...	81
,, ,, 6.—December, ,, ...	109
,, ,, 7.—January, 1917	117
,, ,, 8.—February, ,, ...	125
,, ,, 9.—March, ,, ...	149
,, ,, 10.—April, ,, ...	165
,, ,, 11.—May, ,, ...	181
,, ,, 12.—June, ,, ...	205
Erratum	182
Index to *Journal*	237

PAPERS AND NOTES READ BEFORE THE SOCIETY.

Annual Report, 1916-1917, The Council's 205-209
Ash, Neutralization Effect of, on Acid-Sand in Stope Filling, by Chris Toombs, 84-87; Discussion, 87, 135-136; Reply to Discussion 188-189
Assayers' Certificates 190-191
Concrete Shaft Equipment at the Bantjes Consolidated Mines, by W. W. Lawrie and G. Hildick Smith (Vol. XVI., 202-204; Discussion, 204-205); Reply to Discussion 96-97
Conglomerates of the Witwatersrand, The, by Dr. E. T. Mellor (Vol. XVI., 144-180; Discussion, 180-181, 193-194, 206-211, 230-233); Reply to Discussion 41-45
Dust Filters, Sugar for, by R. A. Cooper, 165-166; Discussion, 166 182
Ear Defenders, by A. J. Herald 81-82
Explosives, Testing the Strength of, by J. A. Campbell, 66-69; Discussion, 69 135
Fire Damp, Some Notes on Explosions of, and Occurrences of Gob Fires in Natal, by J. E. Vaughan and F. A. Steart, 217-225; Discussion 225-226
First-Aid on the Mines, by T. P. Waites, 211-212; Discussion 212-213
First Aid Work on the Mines, The Encouragement of, Some Suggestions based on Crown Mines Experience, by A. J. Brett (Vol. XVI., 249-253; Discussion, 253-256), 45-48, 97-100; Reply to Discussion 133-134
Flotation Concentration Experiments on a Transvaal Gold Ore, by F. Wartenweiler, 87-88; Discussion, 90, 117-118, 136-137; Reply to Discussion 189
Industrial Research, by The President (Prof. J. A. Wilkinson) 82-84
Lime, The Solubility of, by Andrew F. Crosse, 125-126; Discussion 126-127
Manganese Silver Problem, The, by Walter Neal, 9-18; Discussion, 39-41, 70-71 100
Metals, The Hardening and Annealing of, by Prof. T. Turner, 61-65; Discussion, 65-66 100-103
Minerals, Rare, in Madagascar, Notes on, by T. P. Waites (Vol. XVI., 187-189; Discussion, 211-212, 257), 39; Reply to Discussion 69-70
Natal Coalfields, The, Phases in Development, by Wm. Taylor Heslop, 182-188; Discussion, 188, 227-229
Ore Treatment at the Falcon Mine (Rhodesia), by H. R. Adam, 91-94; Discussion, 94-96, 118, 137-139; Reply to Discussion 226-227
Pilgrims Rest Ore, Notes on Treatment of, by Robert Lindsay, 166-172; Discussion, 172-173 189-190
Presidential Address, The, by Prof. J. A. Wilkinson 27-38
Rust, Removal of, from Iron Plates, by F. W. Watson 109
Shaking Chute for Flat Stopes, by S. Nettleton, 57-60; Discussion 60-61
Silicosis in Rats in a Witwatersrand Mine, by Dr. J. Pratt Johnson, 150-155; Discussion 155-157, 171-175
Slime Dams, The Construction and Maintenance of, by Jas. E. Thomas and E. A. Osterloh, 214-217; Discussion 217
Stamp Milling Costs, Comparison of, between Californian and Nissen Stamps, by K. L. Graham, 118; Discussion, 128; Reply to Discussion 176
Thymolphthalein and Naptholphthalein, New Applications of, including Rapid Methods for Analysing Limestone, and Ammonium Salts, by Dr. J. Moir, 129-132; Discussion, 132, 158 174
Track and Rail Joint, A New, by L. W. Macer, 127-128; Discussion 128
Valuation of Mines, The, by Prof. R. A. Lehfeldt, 1-4; Discussion, 39, 134-135; Reply to Discussion 158

Digitized by the Internet Archive
in 2011 with funding from
University of Toronto

http://www.archive.org/details/journalsouthafri17sout

LIST OF OFFICERS FOR THE YEAR ENDING JUNE, 1917.

Hon. President:

H.E. The Right Hon. Viscount Buxton, P.C., G.C.M.G.

Hon. Vice-Presidents:

His Hon. Sir F. D. P. Chaplin, K.C.M.G.
Hon. F. S. Malan, M.L.A., Minister of Mines and Industries.
E. A. Wallers (President, Transvaal Chamber of Mines).
Sir Lionel Phillips, Bart.
W. H. Dawe.

Past Presidents:

Wm. Bettel, the Late
Andrew F. Crosse,
W. R. Feldtmann,
Charles Butters,
Julius Löevy,
John R. Williams,
S. H. Pearce,
W. A. Caldecott,
William Cullen,
Edward H. Johnson,
John Yates,
R. G. Bevington, the Late
A. McA. Johnston,
James Moir,
C. B. Saner,
Walford R. Dowling
Alex. Richardson,
G. H. Stanley,
Jas. E. Thomas.

President:

J. A. Wilkinson.

Vice-Presidents:

Jas. Gray,
G. Hildick Smith,
H. A. White.

Ordinary Members of Council:

H. R. Adam,
J. Chilton,
K. L. Graham,
W. W. Lawrie,
F. G. Macdonald,
H. S. Meyer,
C. Toombs,
F. Wartenweiler,
F. W. Watson,
John Watson,
E. M. Weston,
A. Whitby.

With the Past-Presidents, who are Members of the Council *ex-officio*.

Corresponding Members of Council:

E. G. Banks,
W. Cullen,
Clement Dixon,
G. T. Holloway,
Walter Neal,
C. H. Pead,
A. Richardson,
W. J. Sharwood,
T. B. Stevens,
Ralph Stokes,
G. M. Taylor,
Gerard W. Williams

Hon. Treasurer:

James Littlejohn.

Hon. Auditors:

Alex. Aiken, and Carter.

Hon. Legal Advisers:

Messrs. van Hulsteyn, Feltham & Ford

Editorial Committee:

J. A. Wilkinson (*Chairman*),
H. R. Adam,
H. Meyer,
J. Moir,
G. Hildick Smith,
A. Whitby,
H. A. White.

Finance Committee:

J. Littlejohn,
Jas. Gray,
John Watson,
J. A. Wilkinson.

Secretary:

Fred. Rowland, Fellow, Chartered Inst. Secretaries,
(P.O. Box 1183; Telephone 1101; Tel. Add.: "Scientific,"
Old Municipal Buildings, De Villiers Street, Johannesburg

APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. JULY 1916. No. 1

This paper will be submitted for discussion at the meeting to be held 16th September, 1916.

THE VALUATION OF MINES.

By Prof. R. A. Lehfeldt, D.Sc.

The problem of estimating the present worth of a mine has usually been dealt with mathematically only to the extent of capitalizing dividends at various assumed rates of interest.[*] Arithmetical examples, dealing more fully with capitalization and working costs are given by some writers,[†] but without an algebraic basis. It is sometimes thought that the data of mining are too uncertain to make it worth while to apply mathematical methods to them: but arithmetical treatment suffers from the disadvantage that it does not show what is the effect of varying the factors involved, so that misleading conclusions may easily be drawn from the more or less accidental cases which are chosen for working out.

In the present paper an attempt is made to deal with the question mathematically with the aid of assumptions that are not too far from the facts to be of practical service.

Let there be a mine containing X tons of ore whose average value is p pounds per ton. The mine is worked on the scale of x tons per year: the working costs on this scale are q pounds per ton, and the capital required C pounds. Let i be the rate of interest.

The life of the mine is $X / x = T$.

In any short time dt the ore milled is xdt, and the working profit made is $(p-q)xdt$.

If the time t be counted from the time of starting the mill, and the value of the mine at that moment is required, each element of profit must be discounted at the rate of e^{-it} so that the whole present worth of the working profit is

$$= \int_0^T e^{-it} \left(p-q\right) x \, dt = \left(p-q\right) x \left\{ \frac{1-e^{-iT}}{i} \right\}$$

but as this can only be obtained by means of the capital outlay C the net value of the mine at the time of starting the mill is

$$V = \left(p-q\right) x \left\{ \frac{1-e^{-iT}}{i} \right\} - C \quad . \; . \; . \; . \quad (1)$$

Here the capital that has been spent earlier must be accumulated at compound interest i up to the given moment; in other words, C is the "accrued capital," in Mr. Kotze's sense of the term.

It will be noticed that this formula is not, like those in the books quoted, based on two rates of interest. That is an inadvisable way of expressing the facts. There is only one rate of interest: the compensation that a capitalist requires on account of the risk of mining is another matter. It is hardly necessary to remark that the rate of interest has long ceased to be anywhere near 3 . At present it is about 5 —the yield on good Government stocks, and some such rate should be taken in dealing with amortisation, and with accumulation of capital expenses.

To make use of the formula for V it is necessary to assume forms for the quantities q and C, which are functions of x. The simplest form that is reasonably near the fact is the linear form. Accordingly I shall put

---

[*] Hoover, H. C., Principles of Mining.
Lawn, J. G., Mine Accounts and Mining Bookkeeping.

[†] Ross Browne, "Working Costs of the Mines of the Witwatersrand." (Appendix 3 Johannesburg, 1907).
Memo on Far East Rand, by the Government Mining Engineer (R. N. Kotze) pp. 8, 14, 15 (Cape Town, 1916).

$$C = C_0 + cx$$

where C_0 and c are constants. This is equivalent to dividing the capital expenditure into two parts, one fixed in amount (for the given mine) the other proportional to the scale of working. The former part may, it is true, be a function of X, the size of the mine, but that point need not be considered for the moment.

Similarly the working costs may be divided into fixed annual charges and a part proportional to the tonnage milled, giving

$$q = \frac{Q}{x} + r$$

where Q and r are constants.

Substituting, and remembering that $x = X/T$ we have

$$V = \left\{(p-r)\frac{X}{T} - Q\right\}\left(\frac{1-e^{-iT}}{i}\right) - C_0 - \frac{cX}{T} \quad . \quad (2)$$

Hence, for a given mine, in order that the present worth should be a maximum the scale of working must be such as to make the life T satisfy the equation

$$\frac{dV}{dT} = 0$$

$$\text{or} -\left\{\frac{(p-r)X}{T^2}\right\}\left(\frac{1-e^{-iT}}{i}\right) + \left\{\frac{(p-r)X}{T} - Q\right\}e^{-iT} + \frac{cX}{T^2} = 0$$

$$\text{or} \quad e^{iT} = \frac{\dfrac{1}{i} - \dfrac{c}{p-r}}{\dfrac{1}{i} + T - \dfrac{QT^2}{X(p-r)}} \quad . \quad . \quad . \quad . \quad (3)$$

This equation cannot be solved directly, but it is easily evaluated with the aid of a table of exponentials.

Through the courtesy of the officials of the Department of Mines, I have obtained some figures representing approximately the constants in the above equations as applied to gold mining in the East Rand area. The figures should not be applied to different conditions without separate consideration: and in particular, the linear form of the expressions for C and q is only applicable within moderate limits of scale. The numbers given below may be regarded as applicable to mines of about 1,000 to 3,000 claims, equipped according to the present standard of mining engineering.

The capital expenditure necessary depends on (i.) the depth, (ii.) extent of the mine, (iii.) scale of working. Accordingly in comparing one mine with another the value of C_0 may vary on account of difference in depth; and c, so far as it depends on shaft sinking will vary too. Further, it is difficult to bring the number of shafts into relation with the extent of the mine, and only through that connection can it be related to the scale of working: moreover, technical practice seems to vary much on this point. On the other hand, the outlay on advance development is approximately proportional to the scale of working, and the cost of equipment depends almost exclusively on the scale of working, but is not proportional to it.

Experience for mines of average depth may be summed up in the values

$C = £500,000$

$c = £1·5$ per ton milled per year.

To check the accuracy of these values I give the comparison between calculation and experience in a few instances.

Capital Expenditure.

	By formula.	Actual.	Years before starting mill.
Brakpan ...	£1,580,000	£1,185,000	7
Geduld ...	950,000	1,100,000	12
Govt. Areas ..	1,400,000	1,570,000	6
Modder Deep...	1,000,000	672,000	5
Van Ryn Deep	1,250,000	1,155,000	8

Working costs vary considerably with depth, but have no direct relation to the extent of the mine. Assuming an average depth of 3,500 ft., they may be represented with sufficient approximation by the formula given above, with

$Q = £150,000$ per year

$r = £0·68$ per ton milled.

The results of the formula $q = Q/x + r$ agree closely with an empirical curve, supplied by the Department of Mines. It yields these results.

x Tons.	q	
600,000	£0·930 or	18/7
900,000	0·847	16/11
1,200,000	0·805	16/1
1,500,000	0·780	15/7

But what is called "working costs" does not cover the whole expenditure of the mines. There are other expenses that it is customary to charge against net revenue, on one pretence or another, thus making the mines seem cheaper to run than they

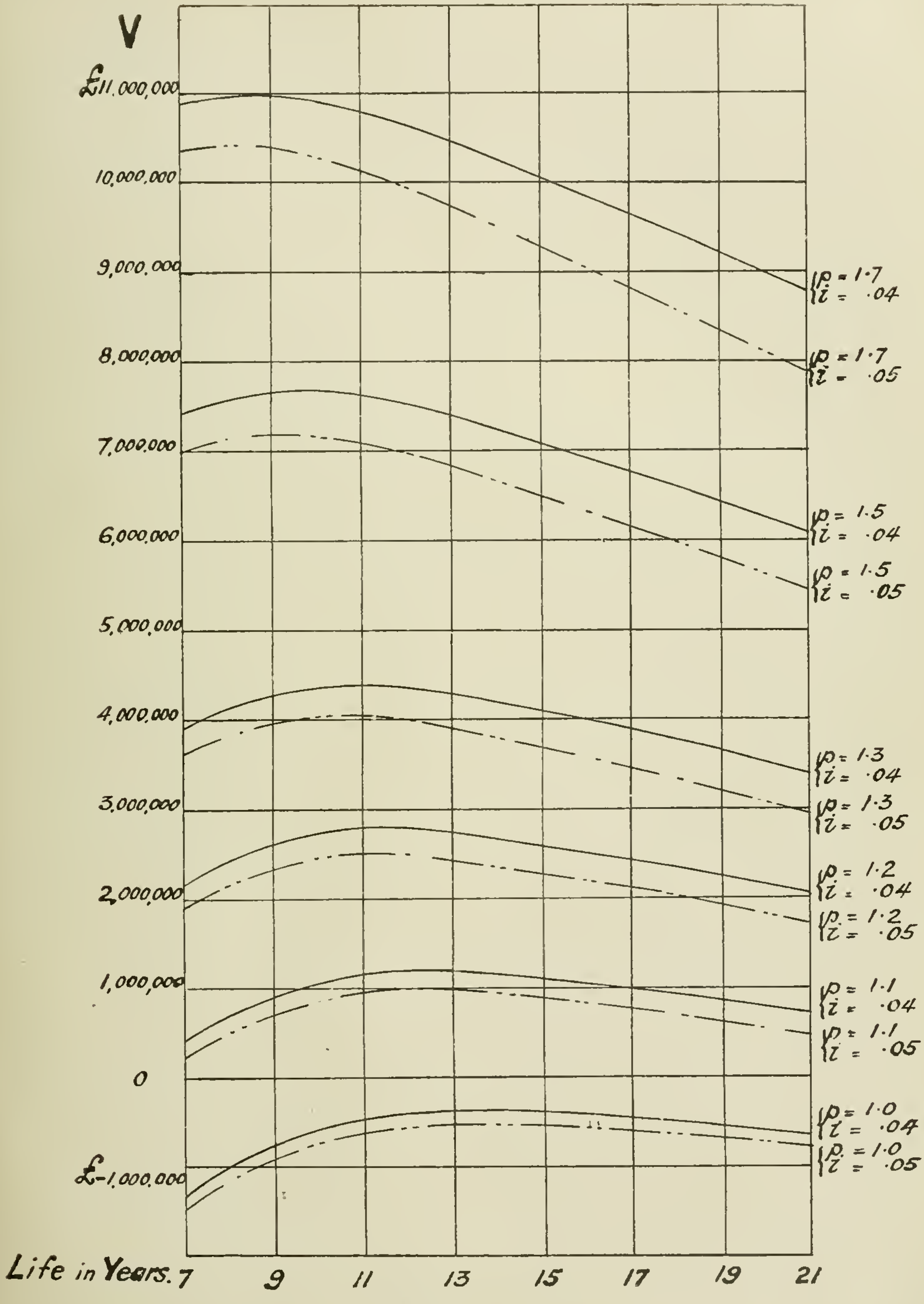


Fig. 1.—p = value of ore in £ per ton.
i = interest.

are. These expenses add quite a shilling a ton, so we will take

r=£0·75 per ton milled

instead of the figure given above.

Further, in working out the most advantageous life of a mine by equation (3) it is necessary to know X. But as this only comes in in a small correction term it will be sufficient to take an average amount, say, 20,000,000 tons.

The results for ore of different grades, taking the rate of interest at either 4% or 5%, are shown on Fig. I.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Analysis of Aluminium and its Alloys.—"*Aluminium-zinc series of alloys* 1—2 gm. of the alloy is dissolved in dilute hydrochloric acid, excess of sodium hydroxide solution added, the solution (400 cc.) heated to boiling, and a rapid stream of hydrogen sulphide passed for 10 minutes. The precipitate is dissolved in hydrochloric acid, ammonium chloride solution added, and the slight amount of aluminium present precipitated by ammonia. The aluminium is reprecipitated twice more in this way, dissolved in hydrochloric acid, and iron determined colorimetrically. The zinc solution is exactly neutralised, and precipitated with a large excess of ammonium phosphate in boiling solution. After cooling, the precipitate is collected on asbestos in a Gooch crucible, ignited gently, and weighed as zinc pyrophosphate. The method gives a zinc sulphide which filters with the greatest ease, and effects, in the case of the richer zinc alloys, a perfect separation. No silica is ever found in the precipitated zinc. *Copper-aluminium alloys.* For alloys with over 10% Cu, estimation of the copper electrolytically, after dissolving the alloy in nitric acid, gives excellent results. When manganese exceeds 2%, however, electrolytically deposited copper is contaminated with manganese dioxide. Alloys poorer in copper are dissolved in dilute hydrochloric acid, the "flocked-out" copper separated, and the remainder precipitated as sulphide. When zinc is also present, the solution must contain at least 12 cc. of hydrochloric acid of sp.gr. 1·1 per 100 cc. to avoid the co-precipitation of zinc. *Alloys containing Cu, Al, Zn, Ni, Mg, and Mn.* 2 gm. of the alloy is dissolved in 30 cc. of hydrochloric acid and 10 cc. of nitric acid, the solution diluted somewhat, treated with 15 cc. of concentrated sulphuric acid, and evaporated till fumes of sulphur trioxide are evolved. After cooling and treating with water, the residue of silicon and silica is filtered off, ignited and weighed in a platinum crucible, and the silica determined by loss after treatment with hydrofluoric and sulphuric acids. The silicon is estimated as the further loss after treatment with hydrofluoric and concentrated nitric acids. Any residue is fused with potassium bisulphate and the solution of the melt added to the main solution. The latter (about 300 cc.) is heated to 70° C., and hydrogen sulphide passed till all the copper is precipitated. The copper sulphide is filtered off for determination of copper, and the filtrate boiled till free from hydrogen sulphide, treated with 15 gm. of tartaric acid, neutralised carefully with ammonia, adding only a very slight excess, treated with 5 gm. of ammonium chloride, heated to 70° C., and hydrogen sulphide again passed. After allowing the solution to stand for a few hours in a closed flask, it is filtered; the precipitate contains the whole of the iron and zinc, and part of the nickel and manganese. The filtrate is made distinctly acid with acetic acid, boiled to remove hydrogen sulphide and to coagulate any colloidal nickel sulphide, filtered, the filtrate concentrated to 800 cc., cooled, made feebly alkaline with ammonia, and an aqueous solution of 5 gm. of sodium phosphate added slowly with vigorous stirring. After the precipitate has formed, one third the bulk of concentrated ammonia solution is added and the whole allowed to stand overnight. Next morning, the precipitate is filtered off, washed, redissolved in hydrochloric acid, and reprecipitated after addition of 1 gm. of tartaric acid. The weighed precipitate is dissolved in very dilute nitric acid, and any silica remaining is weighed. Any manganese present in the solution is estimated colorimetrically, and the corresponding weight of manganese pyrophosphate deducted from the weight of the magnesium precipitate. The mixed sulphides precipitate is dissolved in hydrochloric acid, and the iron oxidised with a little nitric acid. The iron is removed as basic acetate, reprecipitated with ammonia, and weighed as oxide. Traces of manganese are removed by bromine, the zinc precipitated as sulphide in formic acid solution, redissolved if in large amount, and determined as pyrophosphate. The nickel is determined in the solution either volumetrically or by dimethylglyoxime. Manganese is estimated on a separate portion of the alloy by the bismuthate method, as manganese largely remains in solution with the aluminium. Results obtained on mixed solutions containing known amounts of Al, Mg, Fe, Zn, and Ni are given, and demonstrate the accuracy of the method. The author gives an account of the method used for the complete analysis of several samples of the purest commercial metal containing from 99·0% to 99·5% Al. Sodium is now rarely found as an impurity. It may be determined by dissolving the metal in nitric acid, igniting the nitrates, and extracting with water."—W. H. Withey, *Inst. of Metals*, March, 1916.—*Journ. Soc. Chem. Ind.*, April 29, 1916, p. 472. (A. W.)

Acceleration of Kjeldahl's Method of Determining Nitrogen in Coal and Coke.—"The digestion with sulphuric acid in the preliminary stage of the Kjeldahl process for the determination of nitrogen in coke, may frequently be materially shortened by the use of asbestos (1 gm.) impregnated with copper oxide (0·8 gm.). With soft cokes, a longer time is required with asbestos (1 part) impregnated with tungsten trioxide (2 parts) than when mercuric oxide is used. The favourable action of tungstic acid is most noticeable with hard cokes. For example, a specimen which was hardly affected by 19 hours' digestion in presence of mercuric oxide, was ready for distillation after 8 hours' digestion in presence of tungstic acid. By using mercuric oxide, copper oxide, potassium bisulphate, etc., in addition to asbestos impregnated with tungstic acid, the period of digestion may be reduced to 1 to 2 hours. In the case of coal, the addition of mercuric oxide (0·5 gm. per 1 gm.) effects a great reduction in the time of digestion (*e.g.*, 9 hours to 1 hour), whereas tungstic acid has much less effect. Retort graphite was decomposed in 9 hours in presence of 2 gm. of asbestos impregnated with tungstic acid, but was not altered by 25 hours' digestion in presence of mercuric oxide (0·5 gm.). B. M. Margosches and A. Lang, *Chem.-Zeit*, 1915, *39*, 673-675.—*Journ. Soc. Chem. Ind.*, Oct. 30, 1915, p. 1013. (J. A. W.)

Utilisation of Wood Waste.—"It is estimated that in the United States at least 75,000,000,000 ft. board measure (about 112,000,000 tons) of wood waste is produced annually. Numerous experiments have been made under the author's direction on the utilisation of long-leaf yellow pine waste, the annual production of which is equivalent to 30,000,000,000 ft. board measure, and it is estimated that this amount would provide sufficient raw material for the daily production of 40,000 tons of paper, 3,000 tons of rosin, 300,000 gallons of turpentine, and 600,000 gallons of alcohol, together with sufficient fuel to manufacture these products. Long-leaf pine logging waste, "bone dry," weighs about 39·1 lb. per cub. ft. The length of the fibres varies from 3 mm. to 7·4 mm., average 4·6 mm., as compared with 3 mm. to 3·5 mm. for spruce. An excellent pulp for "kraft-paper" can be obtained from the wood by the sulphate process, the yield being about 1 ton of paper from 1½ cords of round waste, as compared with 2 cords in the case of spruce wood. Alcohol has been produced on a commercial scale from the waste by the Ewen-Tomlinson process (see Von Demuth, this J., 1911, 71); the yield is 10 galls. of 95% alcohol per cord of sawdust or hogged wood waste containing 50% of water, and the alcohol can be produced at a cost, including cooperage and fixed and manufacturing charges, of not more than 20 cents a gallon. By using hydrochloric instead of sulphuric acid, removing most of the acid from the digested material by heating or by a blast of air, and neutralising the remainder with sodium carbonate, then extracting the juice and concentrating it to a syrup, the process may be adapted to the production of a carbohydrate cattle food (see U.S. Pat. 1,092,221 of 1914; this J. 1914, 563). Stump wood may be treated by a solvent extraction process, yielding 6 galls. of turpentine, 2½ galls. of pine oil, and 380 lb. of rosin per cord, and the extracted chips can be used for the production of paper pulp or alcohol; or the stump wood and other highly resinous waste may be destructively distilled, yielding 6 galls. of light oils, 6 galls. of turpentine, 16 galls. of heavy oil, 48 galls. of tar, and 35 bushels of charcoal per cord. The various processes proposed for the recovery of turpentine, pine oil, and resin from the waste by extraction with dilute aqueous alkali have not proved successful commercially owing to the difficulty of separating from the resin the "humus" produced by the action of the alkali on the wood. In a process devised by Whitaker and Bates this difficulty has been overcome by increasing to 3½% of free alkali the concentration of the alkaline solution after the initial treatment of the wood, and thereby salting out the resin soap."—A. D. Little, *Amer. Inst. Chem. Eng.*, Jan. 12, 1916; *Met. and Chem. Eng.*, 1916, *14*, 133-135.—*Journ. Soc. Chem. Ind.*, March 15, 1916, p. 301. (J. A. W.)

METALLURGY.

Zinc in Canada.—"In our last issue, our Toronto correspondent mentioned that the Canadian Government intended to offer a bounty on zinc produced within the Dominion. In this connection an article on 'Zinc in Canada,' by Alfred Stansfield appearing in the September *Bulletin* of the Canadian Mining Institute will be of interest. Dr. Stansfield is the professor of metallurgy in the McGill University, Montreal.

The urgent need of zinc for the manufacture of war munitions has led to the production of spelter in Canada from Canadian ores. A Commission consisting of Col. D. Carnegie, Dr. A. W. G. Wilson, and Dr. Stansfield, was appointed some months ago by Major-General Samuel Hughes, the Minister of Militia and Defence, who early in the war saw the necessity of obtaining Canadian zinc for munitions. This Commission has been studying the supplies of Canadian ores, and the means available for turning them into spelter, suitable for the manufacture of ammunition. As a result of this work, and of the enterprise of Canadian metallurgists, spelter will now be produced in Canada, suitable in quality and quantity to meet the local needs of the British War Office and the Canadian Shell Committee. A number of years have elapsed since the value of the Canadian zinc ores was recognized, but until the present time there has been no commercial production of spelter in the Dominion. Zinc, which is mostly found in British Columbia, is associated with lead, and owing to its harmful effect on the dressing and smelting of lead ores, its presence has perhaps been more of a curse than a blessing to the miners and smelters of that province. For several years, however, shipments of zinc concentrate have been made to smelters in the United States, these shipments rising to about 9,000 tons per year. The amount of zinc concentrate that was shipped to the United States is only a small part of that which would be available if suitable methods for its treatment were developed, and Canadian ores should furnish enough for the normal Canadian requirement. Owing to the long freight haul, United States duties, and other drawbacks, these sales have not been very profitable, and several attempts have been made to smelt the ores in Canada. In the year 1904, a zinc smelter was erected at Frank, Alberta, but proved unsatisfactory and was abandoned, largely because the majority of Canadian zinc ores were unsuitable for treatment by the standard method of smelting.

The electric smelting of zinc appeared, for a time, to offer a means for the treatment of the British Columbia ores, and experiments were made at Nelson in 1908 by F. K. Snyder, and at McGill University in 1910 and Nelson in 1913 by the Department of Mines. Owing mainly to a serious difficulty in regard to the condensation of zinc in the electric furnace, none of these experiments has led to commercial operation. In the meantime, experimenters had been looking into the possibility of leaching and electrolytic methods for treating the British Columbia ores. The methods employed here cannot be considered as new except in points of detail; they have been tried many times before and have in general been found unsuitable for commercial use. With the inducement of the present high prices of spelter, the problem was taken up with renewed energy, and technical success obtained; while arrangements have now been completed with the British War Office, the Dominion Government, and the Shell Committee that will enable the manufacturers to proceed with the production of spelter on a commercial scale. The methods employed by different metallurgists differ in detail, but the process consists generally in roasting the ore, thus forming oxide and sulphate of zinc, which are extracted with the aid of sulphuric acid and water. The zinc sulphate solution is electrolyzed, using insoluble anodes and sheet-metal cathodes. The zinc is deposited in a metallic layer on the cathodes, and sulphuric acid is liberated and is used for the treatment of fresh lots of ore. When, as is usually the case, the ore contains lead as well as zinc, the lead remains in the ore-residue, and can be smelted in the usual way. In making brass for cartridge cases very pure zinc must be used, the ordinary brand of spelter not being pure enough. The British Columbia ores contain so much lead that if they were smelted by the ordinary methods the resulting spelter would be far too impure for use in ammunition-making, so, for this purpose, the electrolytic method can alone be used. The need of a specially pure spelter for the manufacture of ammunition constitutes an important reason for using the electrolytic method, instead of the standard process of zinc smelting, or even the electric furnace method, for the treatment of the British Columbia ores.

Among the companies now engaged in the production of zinc in Canada by electrolytic methods, may be mentioned the Consolidated Mining and Smelting Co., at Trail; the Standard Silver Lead Mining Co., near Silverton, using the French process; and the Weedon Mining Co., using the Watts process in a new plant at Welland. Under present conditions the main idea must be the rapid production of metal to serve the Empire's need, but it is satisfactory to realise that the present situation has served to start a new industry, which, in happier times, will materially benefit the mining and smelting enterprises of British Columbia and other parts of Canada, and will incidently open the way for a considerable increase in industrial metallurgy in the Dominion."—Dr. Stansfield, *Bulletin*, Canadian Mining Institute. — *Mining Magazine*, Oct., 1915, Vol. XIII., No. 4, p. 227. (J. E. T.)

The Influence of Oxygen on Some Properties of Pure Iron.—"Mr. Wesley Austin, M.Sc., makes this the title of a paper to the Iron and Steel Institute. Highly oxygenated alloys were prepared by melting iron and iron-oxide in a small 'Girod' furnace. The material worked upon contained 0·21% oxygen.

It was found that the oxygen had no influence upon the melting point of the iron so far as could be determined on the apparatus available. By micrographic examination it is shown that oxide inclusions can be reduced in a stream of hydrogen at 700° C. The oxide disappears and the hydrogen etches the ferrite strongly.

From observations in rolling and from Charpy tests, it is stated the forging and rolling can be carried out on oxygenated iron at above 950° C. and between 750° and 850° C."—T. Swinden, Transactions, Iron and Steel Institute. *The Engineering Review*, Oct. 15, 1915, Vol. 29, No. 4, p. 117. (J. E. T.)

The Melting Point of Tungsten.—"An interesting note on this subject appeared in the August issue of the *Physical Review* by Mr. Irving Langmuir. The method used was based on Nernst's work, in which he found that the temperature of a black body could be expressed as a function of its intrinsic brilliancy, by an equation. By photometer readings at the time the filament melted in a tungsten filament lamp, the intrinsic brilliancy was calculated.

Pyrometer readings by an instrument of the Holborn-Kurlbaum type were taken independently. By the photometric method, a value of 3,267° C. was obtained, whilst the pyrometer observations gave an average of 3,259° C.

After a careful review of the whole of the possible errors in the various methods, it is concluded that the most probable value for the melting point of tungsten is 3,267° C. ± 30°."—T. Swinden, *Physical Review*—*The Engineering Review*, Oct. 15, 1915, Vol. 29, No. 4, p. 117 (J. E. T.)

The Relative Efficiency of Various Amalgams in the Recovery of Gold.—"A series of tests were carried out to investigate the properties of different amalgams and their efficiency in recovering gold. Various amalgams were prepared which were used for amalgamating copper plates over which the ores were passed, the tests being done under standard conditions. It was found that in the treatment of a simple gold ore, free from impurities, plain mercury was better than any of the amalgams. In the presence of sulphates, such as are frequently found in oxidised ores, the extraction of gold was much reduced, and plain mercury no longer gave the best results. When 5% of zinc sulphate was present, plain mercury dropped to the fourth place. With manganese sulphate and ferrous sulphate plain mercury gave still worse results. Taking into consideration the results obtained under all conditions, lead and tin amalgams gave the best results, with plain mercury third. The relative effect of sulphates in lowering the extraction was also determined. Iron sulphate caused an average drop in recovery of gold of 15·4%, manganese sulphate 20·1%, and zinc sulphate a drop of 25·8%. The injurious effect is due to the sulphates producing a coating on the plates, and the amalgams which gave high extractions show less tendency to coat than the others. Mercury has apparently a greater affinity for gold when pure than when any other metal is amalgamated with it. In those cases where amalgam shows a higher extraction than mercury alone, the effect is not caused by any increased efficiency due to the presence of the various metals, but rather to the superior resistance of the amalgam to the deteriorating influence of impurities. Cadmium amalgam maintained a clean and bright surface, but gave very low recoveries under all conditions. Lead amalgam formed a somewhat gritty amalgamated surface, and was difficult to apply clean. It maintained its bright surface and gave the best all round extractions. Tin amalgam gave a bright, clean surface, which remained bright; its all round recoveries were slightly lower than lead. Gold, silver, sodium, and zinc amalgams followed in that order. Plain mercury gave the highest extraction on pure ores, but tarnished worst of all with impurities, when its recovery was lower than most of the amalgams. The low recovery obtained with gold amalgam indicates the necessity for removing this amalgam at frequent intervals." Thomson and Keffer. *Met. Chem. Eng.*, 13, 367. —*Mining and Engineering Review*, Nov. 5, 1915, p. 45. (J. E. T.)

Hall Process for Removing Sulphur from Ores. "A process for desulphurizing ores is being tried in the United States, and is stated to be giving very successful results. It consists in subjecting the crushed ore to the direct action of a reducing or non-oxidising blow-pipe flame and steam, keeping the ore between 700° and 925° Cent. Under these conditions free sulphur distils off, and very little sulphur dioxide or sulphuretted hydrogen is formed. When carried out in multiple hearth furnaces, 100 lb. to 125 lb. of ore per square foot of hearth area may be treated per day, leaving less than 1% of sulphur in the product. The volatilized sulphur is extracted from the fumes by washing, or precipitated electrolytically by the Cottrell process. The recovered sulphur is from 98% to 99·5% pure." *Mining and Engineering Review*, Nov. 5, 1915, p. 45. (J. E. T.)

New Fine Screens.—"The Multi Metal Separating Screen Co., of New York, has succeeded in making 350-mesh screens (122,500 apertures per sq. in.) of vanadium-bronze wire about 0·001in. diameter, with which different operators, using different screens, can obtain concordant results, according to C. D. Holley and J. C. Brier, *Oil, Paint and Drug Reporter*, May 10, 1915; abstr. *Journ. Soc. Chem. Ind.*, June 15, 1915. These screens have proved of value for testing the fineness of pigments. The particles passing through can be ground economically in a paint mill, but those retained on the screen, even when present in relatively small amounts, rapidly reduce the efficiency of the mill. The sample (25 gm.) is washed through the screen by means of water, using a soft brush to break up lumps. Calcium and manganese oxides, as used by varnish manufacturers, can be tested in a similar manner, using naphtha instead of water. The results obtained with consignments of various commercial pigments varied greatly in many cases from those yielded by the small sample used as a basis of purchase." *Engineering and Mining Journal*, p. 563. (H. A. W.)

Hardening High-Speed Steel for Machine Tools. "Writing to *Iron Age*, Mr. R. A. Millholland recently said, much good steel is wasted through poor practice in heat treatment.

Naturally a tool improperly hardened has to be ground oftener than a properly hardened one, and the result is a serious loss in manufacturing time and a waste of perfectly good high-speed steel. All up-to-date methods may be practised in the hardening, and yet tthe tool may prove unsatisfactory when run at the speed and feed that high-speed steel will stand when properly treated. Some of the most serious trouble has been experienced in the hardening of steel machine tools, such as special shaped cutting-off tools, box turning tools, and facing tools—in fact, any tool that is ground from the annealed bars as they are received from the mill, and has one of the cutting edges on one of the sides of the annealed bar. Especially is this true of the box-turning tool, where generally little or nothing is ground from the face of the tool stock.

Most of these tools are made from ½ in. 1 in. stock, and require no forging before they are ground on the emery wheel. The practice of making stock removing screw machine tools should not differ in any essential from the making of taps and the more delicate tools that are made in the tool-room. What competent toolmaker would think of making an expensive tool from a piece of stock that was just large enough to 'clean up?' Did you ever stop to consider why the experienced toolmaker always turns off at least 5% of the diameter before attempting to make a tool that must have an enduring cutting edge?

The theory is the same for large and small tools. The reason is that the annealing bars as received from the mill have a thin shell of decarbonised scale so to speak, on the outside. This decarbonised area must be removed before a good cutting edge can be secured that will harden satisfactorily. A simple method for doing this is to grind the tool to its approximate shape and then put in the milling machine and remove about 5% of the thickness of the stock from the surface that is to be the cutting edge. If this is done, when the tool is properly hardened it will have its maximum cutting capacity, and will run longer on fewer grindings than will the tool made from the rough stock without first removing the decarbonised area.

The practice of disregarding the decarbonised area in all forms of tool steel always has been and always will be a great source of loss in the efficiency of the tool, and the cause of excessive tool steel bills." R. A. Millholland, *Iron Age*.—*Page's Engineering Weekly*, Dec. 24, 1915, p. 433. (J. E. T.)

The Callow Pneumatic Oil Flotation Process. "The author gives a detailed description of his process as installed at numerous lead-zinc and copper mines in the United States.

The principle of the process is to obtain a froth by blowing air through a porous material such as canvas twill into the ore pulp containing a mixture of tar, tar oils or pine oils. The oil may be mixed with the thickened pulp in a Pachuca vat or simply in the tube mill itself.

The separation into concentrate bearing froth and tailing takes place first in a roughing cell (see diagram), a wooden vat about 9 ft. long, 24 in. wide and with a sloping bottom, the depth at the shallow end being 20 in. and at the deep end 45 in.; the bottom of the vat is made of the canvas twill backed with perforated metal. From the roughing cell the concentrate froth is conveyed to a cleaner cell of a similar construction. One cleaner cell is sufficient for four or more roughing cells.

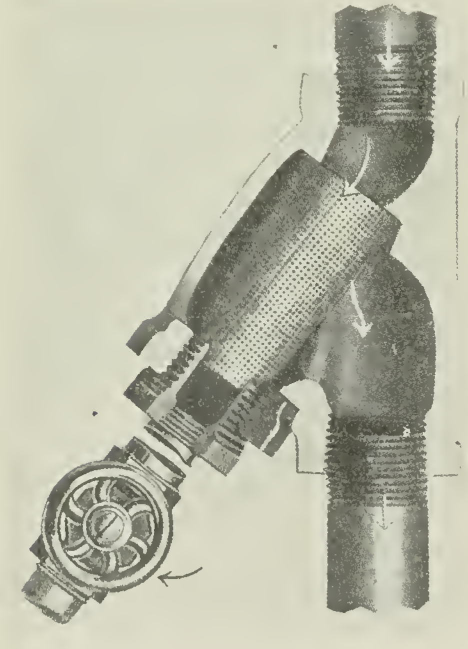
The author discusses at some length an electrostatic theory of flotation which briefly stated is that flotable particles have positive charges of electricity and are attracted to the froth which is negatively electrified." —J. M. Callow.—*Mining and Engineering World*, Dec. 4, 1915, pp. 887-894. (H. R. A.)

Analysis of Turbadium Bronze.—"Turbadium bronze contains approximately Cu 48, Zn 46·45, Sn 0·5, Pb 0·1, Fe 1, Al 0·2, Mn 1·75, and Ni 2%; it has a tensile strength of 35—42 tons per sq. in., and elongation (on 2 in. test-piece) 11—20%. It is used for making solid propeller castings, as it is not corroded appreciably by sea water." H. Williams, *Chem. News*, 1915, *112*, 175-176. *Journ. Soc. Chem. Ind.*, Oct. 30, 1915, p. 1057. (J. A. W.)

MISCELLANEOUS

A Self-Cleaning Strainer for Mine Pipes. "An innovation which promises to reduce many of the troubles of mine engineers in the operation and maintenance of steam, water and air lines is shown by the accompanying illustration of a self-cleaning strainer of the strait-a-way type. This device protects the vital parts of the apparatus, increases the life of valves, pumps, traps, reducing valves, pressure regulators, etc. It is simple in construction, easily installed in any pipe line and in self-cleaning. It is composed of a cast-iron body having a perforated brass strainer cylinder, the area of which is several times that of the inlet or outlet, which permits the use of very small perforations without checking the flow of steam in the least. The self-cleaning feature is most valuable as it permits cleaning of the strainer by simply opening the blow-off valve, without removing the strainer from the body.

The construction of the strainer body permits its installation on either horizontal or vertical lines. And when steam is shut off from the line and the blow-off valve is open, the steam line is drained of all condensation, which prevents freezing up in winter. Installation of the strainer in steam lines prevents dirt, grit, scale and all foreign substance from entering the apparatus which it protects, and retains them within the strainer body, whence it may be blown out by simply opening the blow-off valve at the bottom of the strainer.

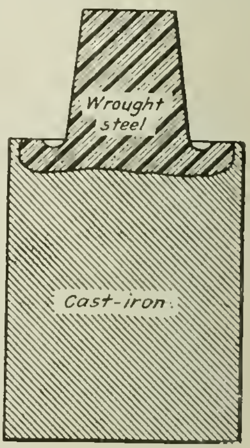


SELF-CLEANING STRAINER FOR MINE PIPES

When installed in water lines it prevents all foreign matter from entering the water supply, as all foreign matter is retained within the strainer body until ejected through blow-off valve.

The brass strainer cylinders have perforations ranging from 1/64in. to $\frac{1}{8}$in. inclusive. Strainer cylinders having 1/64in. perforations are furnished unless otherwise specified, and are suitable for either steam, air or gas service. Strainer cylinders having 3/64in. perforations are furnished for liquid service unless otherwise specified. Strainer cylinders with any size perforations listed can be supplied. The strainers are made in sizes from $\frac{1}{2}$ in. to 3 in."—*Mining and Engineering World*, March 18, 1916, p. 576. (H. R. A.)

Improvised Stamp-Shoes.—"During a period when it was impossible to import steel shoes and dies for stamp batteries owing to lack of communication, Mr. Hubard P. Orr, mechanical engineer in charge of the shops and foundry of one of the large mining companies here, successfully tided over the shortage of shoes by means which it seems to us are worthy of record.



The necks of worn-out shoes, after being thoroughly cleaned on the face, were put into sand, the surface liberally sprinkled with borax and hard iron poured centrally into the mould formed by a pattern of the shoe, the result being complete fusion of the iron to the steel neck. See sketch enclosed. These shoes are running at present without showing any sign of weakness. This may have been done elsewhere, but had not been heard of here and no less credit belongs to Mr. Orr."—Grothe and Carter.—*Mining and Scientific Press*, April 1, 1916, p. 467. (J. E. T.)

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Anderson, P. von M., *l/o* Roodepoort; Geduld Proprietary Mines, Ltd., P.O. Box 41, Springs.

Byerley, B. G., *to* Private Bag, Salisbury, Rhodesia.

Dewar, T. N., *l/o* East Rand; P.O. Box 2, Maraisburg.

Kelly, A., *l/o* Pilgrims Rest; Crown Mines, Ltd., P.O. Box 103, Crown Mines.

Murdoch, R., *l/o* Florida; City & Suburban G.M. Co., Ltd., P.O. Box 1026, Johannesburg.

Robottom, A. E., *to* 271, Collins Street, Kalgoorlie, Western Australia.

Russell, W., *l/o* Sabie; Elandsdrift Mine, P.O. Ross Hill

Whaley, W. S., *l/o* Germiston; Trio Mine, Tafuna, *via* Salisbury, Rhodesia.

LIBRARY
APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. AUGUST 1916. No. 2

This paper will be submitted for discussion at the meeting to be held 16th September, 1916.

THE MANGANESE SILVER PROBLEM.

By WALTER NEAL
(Corresponding Member of Council).

For some four years past I have looked forward to the time when I might present for your consideration a report which should contain a definite solution of the difficulties encountered in the treatment of rebellious manganese-silver ores, but the task is still unfinished, and I offer the following notes as a review of progress and in the hope that they will elicit discussion and suggestions which will advance the work.

The insolubility in cyanide of the silver in certain ores where it is accompanied by manganese oxides has been mentioned by various writers. The literature on the subject is scant, and such clippings as I had accumulated are still within the confines of our sister republic to the South; if, indeed, they still exist. The problem is complicated by the fact that the exact nature of the rebellious mineral is not known—whether there is a definite chemical combination of the manganese and the silver, or whether the manganese functions as an insoluble coating over the silver mineral is not yet established. Not all silver ores carrying manganese oxides are rebellious, and not all the silver in a given rebellious ore is insoluble. Generally, in an ore from a certain ore body a definite percentage of the silver is soluble and the rest quite insoluble. Furthermore, the ratio of soluble to insoluble silver does not vary with the manganese content of the ore nor does the total silver content vary with the manganese content.

Only the manganese occurring as oxide interferes with the solubility of the silver in the ore, and silver occurring with rhodonite or rhodochrosite is generally readily soluble. For this reason it has been usual, where trouble with extractions has been traced to the presence of manganese, to seek more docile ores at depth, leaving the oxidized ores to be treated at some future date.

My own experience with the manganese silver problem dates from May, 1912, when I assumed the management of the El Favor and the Mololoa Mines in the Hostotipaquillo District, State of Jalisco, Mexico, and the experiments which form the subject of this paper were all made on ores from the El Favor mine. The Mololoa vein also carries manganese oxides at the outcrop, but the ore from the lower levels carries silver in the sulphide form and is easily cyanided. It may be remarked that the ore from the Mololoa mine was treated by the patio process in the old times with excellent results, whereas the equally well known ores of the neighbouring El Favor vein were as rebellious to patio treatment as they now are to cyaniding. On the El Favor vein the manganese oxides persist to the present lowest level, some 800 ft. below the outcrop, and owing to its rebellious nature only the highest grade streaks of ore were removed by the ancients. The El Favor mine was well known to the early miners and metallurgists, but owing to the rebellious character of its silver, large reserves of ore of excellent grade (20 oz. of silver per ton and upwards) were left intact.

Apart from the rebellious nature of the ore, working conditions are excellent, and in 1906 Makeever Brothers, of New York, acquired the group of mines and erected a modern stamp mill with Wilfley tables, vanners, tube mills and all-slime cyanide plant. Results were discouraging at the start, but by shipping the higher-grade ores to the smelters and by the strictest economy in management, the business was finally placed on a profitable basis, which continued during 1913 and 1914 up to the time of the American invasion of Vera Cruz in April of the latter year. This resulted in a popular uprising against Americans in the district, and caused a suspension of operations. The mines are at present idle awaiting a solution of Mexico's internal problems.

It is my object in this paper to present a resume of the work which has been done on the metallurgical problem, and I shall largely abstract from the reports of the various investigations. Should it be urged that I should give more definite figures and fewer generalities, I must reply that the mass of data collected is such that any one of the reports on special lines of research would supply material for a paper longer than this.

The El Favor Company exploits an almost vertical vein of quartz in andesite. The ore is highly silicious and darkened by manganese oxides. A partial analysis of a representative sample is as follows:—

Manganese	3·49%
Sulphur	0·67%
Iron	0·70%
Calcium	0·42%
Copper	Trace
Silver	20 oz. per ton
Gold	0·075 oz. per ton

Manganese is present in the form of oxides in the upper levels of the mine, although rhodonite and rhodochrosite also appear in the lower levels. Iron is present both as pyrite and in the oxide form. Silver in the higher grade ores is often observed as a chloride, but direct observation of its rebellious form in the ores under discussion is lacking. A trace of copper appears in the concentrate, but so small is the amount that it is not found in assays of the ore. Gold generally occurs in a ratio of 3 to 1,000 of silver. The gold is readily soluble in cyanide, and extractions of over 90% are consistently obtained in the mill. The ores as described yield to milling 10% of their silver as a concentrate, assaying from 100 oz. to 150 oz. per ton and 40% to 45% as bullion from the cyanide plant.

Mr. F. B. Laney, microscopist of the United States Bureau of Mines' Experimental Station at Salt Lake City, kindly offered to make a microscopic analysis of the ore in an endeavour to determine the character of the rebellious silver. My attempts to get some high grade specimens of the ore from Mexico for this purpose have, however, been fruitless, and as an alternative the highest grade concentrate possible was made from the ore available, and on this material Mr. Laney reports as follows:—

"What appears to be the predominating silver mineral both in the high grade flotation concentrate as also in the gravity concentrate from the same, is proustite, and reacts for silver and arsenic. Bismuth and antimony are absent. Galena, sphalerite, chalcopyrite and covellite are present in minute amounts. The manganese is present as a mixture of oxides, principally psilomelane, and possibly pyrolusite."

The first serious work done on the metallurgy of the ores was in 1911, when E. M. Hamilton was commissioned to make a study of the difficulty. After investigating various possible processes, he recommended the removal of the manganese by solution in sulphurous acid with cyanidation of the bleached tailing. This treatment promised an extraction of 90% of the silver, and so far as could be determined by experiments on a laboratory scale offered an acceptable process. In view of the expense of installing a test plant on a scale adequate to try it commercially, it was decided to exhaust other possibilities before proceeding. Consequently, when I took charge the following year, it was with Mr. Hamilton's excellent report before me and with the determination to try any and every process that offered the slightest promise.

The first step was to exhaust the possibilities of hydraulic concentration. A sample consisting of the discard of the shipping ore was tested in a plant arranged at the Casados Mine by Mr. Syd. D. Kempton, and consisting of a home-made jig and a Deister No. 2 Concentrator. Samples were taken at all points on the flow sheet, and these samples were later cyanided to determine if there was any concentration of either the rebellious or the soluble silver minerals. Table 1 shows results obtained, assays being in ounces troy per ton of 2,000. lb. :—

Product.	Assay.	Assay after Cyaniding.	Extraction by Cyanide.
Original Sample ...	40·7	24·4	40·3
Hutch	47·1	32·4	31·2
Jig Tailing . .	17·6	11·8	33·3
Deister Conc.	98·5	60·0	39·1
,, ,, Fine ...	103·0	79·4	22·8
,, Middling . .	44·2	27·1	38·8
,, Tailing .	35·3	17·6	50·0
Finest slime from tail	25·3	14·7	41·8

The Deister concentrate was of sufficient value to justify shipping to the smelter. However, it only accounted for 18·8% of the silver in the head. There is no concentration either of the rebellious or of the soluble silver, and the best extraction obtained at any point was 50%. At no point was anything found suggestive of improvements that might be adapted to the plant.

Similar tests were made by the Denver Engineering Works, and the following products assayed :—

Product	Assay.
Jig Feed. –4+8 mesh	23·6
,, Conc. 4+8 mesh	47·8
,, (2nd run) –4+8 mesh	44·9
,, Tailing 4+8 mesh	16·4
Classifier. 12 mesh. Coarse spigot ...	36·1
Classifier. Fine spigot	25·0
Slime overflow	24·9

Experiments made locally offered no promise along lines of wet concentration, and in fact the vanners were finally scrapped, leaving only the Wilfleys in the concentration department. Other processes were investigated, among the first was that of the Huff Electrostatic Separator Company, which reported as follows on a sample sent them :—

"The ore was first crushed to 10 mesh and sized on 20, 60 and 200 mesh screens, giving, with the –200 mesh product, four sizes, which were treated separately on the Huff machine."

Assay of original sample 21·8 oz. silver.

Product.	of Total Ore.	Assay	Contents of Products.	of Values.
CONCENTRATE.				
10-20 mesh ...	13·3	14·4	5·91	23·9
20-60 mesh .	7·6	55·8	4·25	17·1
60-200 mesh ..	4·1	27·1	1·11	4·5
MIDDLING.				
10-20 mesh ...	7·6	18·8	1·43	5·8
20-60 mesh ...	5·3	19·0	1·01	4·0
60-200 mesh .	2·2	37·8	·83	3·3
TAILING.				
10-20 mesh ..	22·5	9·3	2·09	8·5
20-60 mesh ..	21·0	8·9	1·87	7·6
60-200 mesh ..	7·7	16·0	1·23	5·0
Through 200 mesh	8·7	28·4	2·47	10·0
Unaccounted for..			2·60	10·3
			24·80	100·0

The darker minerals separated rather cleanly from the lighter and the tailing would have given an improved extraction by cyanide, but as the silver concentrate was not high enough in value to stand the shipping charges, the process alone offers no solution of the troubles.

Experiments were conducted at the Boston Institute of Technology, under the direction of Prof. Edw. D. Bugbee. After preliminary tests with various processes, he recommended magnetic separation on Wetherill machines, followed by chloridizing roasting and cyaniding of the calcine and direct cyaniding of the Wetherill tailing. I quote from Prof. Bugbee's report as follows :—

"By chloridizing roasting, followed by cyanidation or hypo leaching, the magnetic concentrate ought to yield a much better extraction than we obtained in our test, and the magnetic tailing might be made to yield more than the 70% we were able to get. By the combined process it seems that at least 70% to 80% of the silver in the original ore could be recovered. The cost of doing this would naturally be greater than that of direct cyanide treatment, but not enough more to eat up the added gain in extraction. Magnetic concentration is a comparatively simple operation and requires little attention. Only a small fraction, not over one-fifth, of the original ore would require chloridizing roasting (in case this method would be found more economical than shipment to a smelter) and the rest of the ore would be given ordinary cyanide treatment."

The best concentrate obtained assayed

78 oz. per ton, so under the conditions at El Favor it would be necessary to treat the concentrate locally; that is, by chloridizing and cyaniding.

These tests gave higher grade concentrate than had been obtained on the Huff machine and the process as outlined possesses attractive possibilities. While the total extractions indicated are not high, they present an improvement over present practice, and an advantage lies in the fact that only standard machines and processes are proposed. The process outlined by Prof. Bugbee undoubtedly offered an improvement. One objection to its adoption at El Favor was that it involved dry crushing, and it was hoped that a wet process could be developed that would be more easily adapted to the equipment at present installed at the El Favor mill.

An elaborate series of tests was carried out by the Henry E. Wood Ore Testing Company of Denver, Colo. After describing various tests in detail they summarize:—

"The results of standard treatment by concentration and cyanidation are so thoroughly established that we considered it ill-advised to test further along those lines. We do, however, have to advise that we tested by concentration, passing the tailing reground through a special bromo-cyanide treatment, with no benefit.

"A parallel test on the crude ore with bromo-cyanide gave a 42·8% extraction, in conclusive demonstration of the futility of that treatment.

"Special tests were made by ourselves by electrolysis and cyanimide as used under the Clancy patents and process without benefit in your case. Direct hyposulphite tests, with and without roasting, were not as effective as cyanide.

"The Gottschell process of introducing sulphuric acid with the cyanide was of no assistance; in fact, was a complete failure on your ore. Means of introducing reducing gases or of producing wet chloridization were attempted without sufficient success to warrant further investigation.

"It is known that an oxidizing roast lessens the recovery while an acid treatment improves it . . . .

"It was found that the manganese was easily magnetic under the high-power Wetherill separator, and tests were made on the tailing from the Wetherill on the assumption that the ore, once thoroughly cleaned of the manganese, might be more easily cyanided. The results were disappointing. . . . .

"So persistent has been the tailing assay from all treatments in showing aproximately 30% of the original values present as silver, it even occurred to us that possibly this was not all silver and could be platinum or its associated metals at times present in the silver button. Negative results are again reported simply as a matter of record.

"A compilation of some one hundred tests shows conclusively a benefit in every instance where a reducing element is introduced. In a wet way sodium sulphide was most beneficial but erratic."

Chloridizing roasting appearing to them to be the most promising lead, an elaborate series of tests was made along that line, which they summed up as follows:—

" . . . . . we conclude that you are justified in demanding a recovery by a 2

salt roast and cyaniding 70%

Recovery, ditto plus concentration 80·50%

Furthermore, by exact chloridization and cyanidation you should obtain recovery ... ... 85·0

They reported the most desirable condition as a short roast of 15 minutes' duration at 900° F. with 2½ of salt. They estimate the fuel consumption in a furnace of the Wedge type, under a capacity of 100 tons per 24 hours as 8 gallons crude oil per ton of ore.

The problem was next passed to the Wedge Mechanical Furnace Company. They stated that the fuel consumption estimated by the Henry E. Woods Ore Testing Company was probably approximately correct. They state further:—

" . . . 8 gallons of oil, figured at 7½ cents U.S. Cy. per gallon and figuring castings at about 2½ cents and labour at $2.50 per day working 8 hour shifts, and figuring on a furnace with a capacity of 100 tons per day, would judge your total roasting cost, exclusive of salt, ought not to exceed 80 cents per ton of ore roasted."

Their preliminary tests indicated a volatilization of 12½% of the silver during roasting (which could probably be recovered in a scrubbing tower) and an extraction of silver by cyaniding following chloridizing of 76·7%, which checks fairly well with the Woods tests.

While on the subject of roasting, it may be mentioned that tests made by Mr. Syd. D. Kempton, roasting with 2% salt and cyaniding the calcine for 64 hours with a 0·5% cyanide solution, gave a recovery of 82·3% by assay of tailing. Also that work done in the laboratory of the El Favor Mining Company confirmed the above results, and demonstrated that a very short roast (less than 15 minutes) was quite sufficient for effective chloridizing. At the time the mine was abandoned, a small furnace of the Stetfeldt type was under construction to test the roasting idea on a larger scale.

In view of the tests above cited, there seems to be no doubt that an extraction of 80%, less volatilization losses, should be obtained by chloridizing roasting followed by cyaniding.

Experiments made at the El Favor mine and checked at Salt Lake City on reduction of the manganese by roasting in a reducing atmosphere gave promising results, a characteristic test being as follows:—

15 gm. of ore ground to 100 mesh was mixed with 0·75 gm. (5%) powdered coal and roasted in a covered scorifier in a muffle, at about 800° C. for 20 minutes. The roasted ore was agitated in a bottle for 24 hours with a 0·3% solution of potassium cyanide, then washed and filtered. The heads assayed 20 oz. and the tails 5 oz. silver, being an extraction of 75%. This compares favourably with the results of chloridizing roasting and merits careful consideration.

Elmer E. Carey reported extraction of 25·6% by his process of electro-amalgamation.

The Parks Electrocyanide Company succeeded in extracting 40% of the silver in the form of amalgam in seven hours with a consumption of 5·28 lb. of cyanide per ton of ore.

Concurrently with this work an active campaign was carried out locally by myself and the mill superintendent, Mr. H. L. Wilson, both in the plant and in the laboratory. By the time-honoured expedient of getting the tonnage up and the costs down and by improving the mechanics of the treatment, the business was made to show a profit, but the main problem remained unsolved, and we had to contend with a loss of 50% of our silver in the tailing. Mr. Wilson's notes on the work done during this period were unfortunately lost during the rioting which preceded our abandonment of the property, but I quote as follows from a summary made by him as a matter of record after our arrival in the United States:—

"The following incomplete data have been jotted down from memory several months after the last work was done. All notes and data taken during the course of the work have been destroyed.

"The first series of experiments was made to ascertain what effect acid brine would have on the El Favor ores.

"All the common acids were used with different strengths of salt solution. Both leaching and agitation tests were tried, with no results by leaching, and sulphuric proved to be the best acid to use with the salt in the agitation tests. A 2% solution of salt with 2% of acid gave the best results, extracting about 60% of the silver without additional treatment by cyanide.

"This was not satisfactory with the El Favor ores, which carried about 4% of manganese, but with the Cannuchin ores, which carried much more manganese than the El Favor, excellent results were obtained. Heads carrying more or less 34 oz. of silver were reduced to about 2 oz. in the tails after three or four washes with acid brine. Agitation was carried on in closed bottles. The better extraction on Cannuchin ores was due to the larger content of manganese, giving rise to conditions for generating more chlorine.

"All work done on the El Favor ores has indicated the necessity of completely decomposing the manganese in the ore before a satisfactory silver extraction can be obtained. A large number of tests were made along this line, with the result that sulphuric acid, with some chemical capable of taking up oxygen readily, proved to be the best and cheapest method of decomposing the manganese. The chemicals giving the best results were hyposulphite of soda, oxalic acid, sulphate of copper and ferrous sulphate.

"The hypo was very effective in cleaning up the manganese, but used as a preliminary wash it dissolved too much of the silver along with the manganese, making it necessary to provide means for the recovery of the silver from that solution. An attempt was made to complete the extraction of the silver by continued application of the acid hypo solution. This seemed to be doing well enough till reprecipitation of the dissolved values set in about the time that extraction was half completed. Silver was precipitated on iron or any other metal that the solution came in contact with.

"I should have liked to try some of the counter-current methods in which the solution is not allowed to stand but taken off and precipitated continuously and then returned to the charge. As we were anxious to use the installation of iron tanks then in use for cyanide treatment, we looked for some chemical to take the place of the hypo, and found that sulphuric acid and oxalic acid would dissolve the manganese completely and quickly without extracting any of the silver. For this treatment a 2 solution of sulphuric acid with 1 of oxalic acid was found necessary for the preliminary wash to dissolve the manganese, and then a subsequent extraction by cyanide, three or four washes being sufficient to reduce the tails to about 1·7 oz. silver.

"The oxalic acid proved too costly and a cheaper chemical was sought, with the result that (ferrous sulphate of iron was found to be the best and cheapest chemical to use with the sulphuric acid. The dissolving action on the manganese was quicker and perhaps more complete than with any of the other chemicals.

"By using the ferrous sulphate the strength of sulphuric acid was reduced from 2 to 1%, with 1 of ferrous sulphate. A solution containing the above strength of chemicals was used at a dilution of four of solution to one of ore and agitated for three hours. The manganese was completely dissolved as a rule, but occasionally would not be, indicating that a stronger sulphuric acid solution might be used. The pulp was then settled and decanted and washed, and given three or four washes with 0·3 cyanide solution, giving about eight hour periods of agitation. The extraction was satisfactory in most cases, giving a residue in the tails of about 1·4 oz. to 2 oz. silver.

"Equally as good results, and in shorter time, were obtained by not washing the pulp after the preliminary acid wash, but instead allowing the cyanide solution to remain slightly acid.

"I should have liked to have used sulphurous acid in place of the sulphuric, and at the same time the ferrous sulphate.

"A great number of tests that gave negative results were made, such as the use of acid sulphate of soda in place of sulphuric acid. Acid sulphite of soda was also tried. These salts did not dissolve the manganese as readily as one would expect.

"The last work done at the mine was investigating the possibility of treating the concentrate at the mine and shipping bullion. A process which gave possibilities of success and which we were preparing to try on a large scale, consisted of saturating the concentrate with gas oil, or crude oil would have given the same results I think, and then giving a quick roast in a covered dish in a hot muffle. Three to five minutes in a hot muffle gave the best results. After roasting, the concentrate was reground to pass a 200 mesh screen and treated in the usual way with a 0·5 solution of cyanide. Three or four agitations of about ten hours apiece gave satisfactory results, and reduced the silver content from about 136 oz. to 13·6 oz. as tail.

"A short roast in a hot muffle with salt and a subsequent cyanide treatment gave good results also.

"Wet methods of treating the concentrate was not at all satisfactory as there was a large amount of black residue in the concentrate that could not be decomposed by sulphuric acid and ferrous sulphate, and which carried high silver values.

"Other solvents were tried, but no results obtained."

I might add to Mr. Wilson's notes that sulphurous acid has been found to work better both on the ore and on the concentrate than the sulphuric acid he was using.

Since leaving Mexico the research has been carried forward as opportunity offered, mostly on samples secured from Mexico by parcel post during such intervals as mail communication is open with that district, the outstanding features being as follows:—

John D. Fields, of Maxville, Montana, proposed to treat the ore in his electro-flotation cell, and for a time great hopes were entertained of this process. Results, however, were erratic, and occasional promising extractions were offset by the partial failure of confirmatory experiments. Difficulty was also experienced in getting from Mexico sufficient ore for the tests in the rather crude cell used.

Continuing the work of Hamilton and Wilson, some hundreds of tests have been made on processes involving the removal of the manganese with sulphur dioxide.

Naturally the first attempts were bent toward finding a solvent for the silver that would be unaffected by the sulphur dioxide left in the pulp after bleaching the manganese. Saturated salt solutions gave satisfactory extractions, repeated treatments dissolving up to 90% of the silver, but this line was abandoned on account of the difficulties of working economically with saturated solutions of any kind. These tests were varied by electrolyzing the pulp during treatment, but no benefit attributable to the electric current was observed. It was demonstrated, however, that the manganese solution ($MnSO_4$) could be regenerated by precipitating the manganese electrolytically, the regenerated solution being as active as fresh solution. Antimonial lead plates were used for electrodes and the manganese was precipitated as an oxide.

Further tests made with a 10% salt solution (always using the sulphur dioxide) gave some extraction of silver, but less than with stronger solutions.

Combinations of salt with cyanide solutions and electrolysis of the pulp gave results no better than those obtained with cyanide only.

Combinations of salt and ferrous sulphate, with and without electric current, gave no results of promise.

Hyposulphite of soda alone and with salt gave extractions as high as 70% of the silver.

In all the above tests the silver and manganese were together in solution. The tests were not developed to the point of precipitating out the metals.

From this on a double treatment was given the ore, the idea being to dissolve the manganese in the preliminary treatment (bleaching) and dissolve the silver, free from manganese, in a secondary treatment. Sulphur dioxide alone and in combination with other reagents was used for extracting the manganese and hypo for the dissolution of the silver. A characteristic test was as follows:—

50 gm. of ore, ground to 100 mesh, 7.5 gm. of hypo, 250 cc. water and sulphur dioxide were agitated together for 24 hours and filtered on a large Beuchner funnel. The charge on the funnel was next leached for 24 hours with a 3% solution of hypo. The heads assayed 20 oz. silver and the tailing 3 oz., giving an 85% extraction.

The above tests were repeated, agitating the pulp with air in a large separatory funnel in place of leaching. Results showed only a 50% extraction. It was evident that the oxidizing effect of the air agitation was detrimental to the solution of the silver. Mechanical agitation of the pulp with hypo solution gave as good results as leaching. It was found possible to materially reduce both the solution strength and the time of treatment.

It became evident, however, that the precipitation of the manganese from the solution with electric current gave a solution carrying sulphuric acid, which is destructive of hypo. We should therefore, in order to regenerate the acid, have to forego the advantage of immunity to acid which we had hoped to find in the hypo process.

Attention was now turned to a double treatment involving the removal of the manganese with sulphur dioxide and ferrous sulphate, with cyaniding of the bleached tailing. A feature favourable to this process as compared with the hypo process lies in the fact that the ore carries a small amount of gold, which is soluble in cyanide but not in hypo. A characteristic test on this process is as follows:—

50 gm. of ore crushed to 100 mesh, 7.5 gm. ferrous sulphate, 250 cc. water with sulphur dioxide, agitated for 24 hours. Then filtered, washed and agitated for 24 hours with air in a 0.3% solution of cyanide. Head assayed 22 oz. and tailing 1 oz. of silver.

It became evident at this stage that after complete dissolution of the manganese *all* the silver was soluble in cyanide solution. This was rather a surprise in view of the little success attained in the treatment of the concentrate by bleaching followed by cyanide treatment, when attempted in Mexico. However, the tests were checked repeatedly and a practically complete extraction of the silver can be obtained in the manner described. Doubtless the explanation lies in the substitution of sulphurous for sulphuric acid.

Further work along these lines resulted in reducing the time of preliminary (bleaching) treatment to 2 hours maximum and reducing the strength of solution to 1% ferrous sulphate. Reducing the strength of cyanide solution below 0.3% lowered the extraction, but it may be that a longer time of treatment with a lower strength solution would have been as efficient as the use of the stronger solution.

Extraction tests on ore ground coarser than 100 mesh required a longer time of treatment and failed to give such good extractions of the silver. It was also found that by lengthening the time of bleaching, the operation could be accomplished in a thicker (1 : 1) pulp.

The sulphurous acid process gives splendid extraction of the silver, and in fact it may be said that a complete solution of the silver may be obtained by cyanide treatment after bleaching the ore with sulphur dioxide plus another reducing reagent. With recent developments in acid proof filters there remain no mechanical handicaps to the process and the whole operation can be accomplished with standard apparatus. Theoretically, 0·58 parts of sulphur burned to SO_2 will dissolve one part of manganese. There is therefore no prohibitive chemical consumption of reagents to fear. The efficiency of the SO_2, however, remains to be worked out in practice. It is difficultly soluble in water and becomes less soluble with increase of temperature. The El Favor is situated in a semi-tropical climate. It was nevertheless resolved to instal an experimental plant of a capacity of 5 tons per day at the mine as soon as conditions in Mexico make it possible or wise to return.

In the meantime developments on the flotation of the silver have been so encouraging as to make me speculate whether a solution of the problem may not be had along these lines.

During the past winter, by courtesy of the United States Bureau of Mines, I have had the freedom of their Experimental Station at the University of Utah, as also the advice and assistance of the metallurgists of the Bureau, to one and all of whom I wish to record my thanks for their hearty co-operation.

O. L. Ralston, Assistant Metallurgist of the Station, guided me in the flotation of the silver, and excellent results have been obtained to date. The machine used on the experiments was a Janney laboratory flotation machine, capable of treating 500 gm. of ore at a charge (for the most part I used a smaller charge than this on account of the scarcity of the ore). This machine is an excellent one for laboratory work in flotation, and gives results remarkably consistent with larger flotation units.

Flotation of the raw ore gave unpromising results. As a matter of record it may be stated that flotation was attempted in solutions of lime, cyanide, hypo, caustic potash, sodium carbonate and sulphuric acid, with coal tar creosotes, wood creosotes, various pine and pine tar oils, cedar oils and others for frothing reagents. The best results obtained along these lines were as follows:—

400 gm. of ore ground to 100 mesh floated in Janney machine with 2,000 cc. water at 40° C. 20 gm. sodium carbonate and 20 drops 8 Special Pine Tar Oil (from the General Naval Stores Company, of New York) the following products were obtained:—

1st Conc. weighing 6·8 gms. Assay 80·8 ozs./ton acct. for 7·6% Ext.
2nd Conc. weighing 18·9 gms. Assay 40·5 ozs./ton acct. for 10·6% Ext.
3rd Conc. weighing 26·0 gms. Assay 32·6 ozs./ton acct. for 11·7% Ext.

Cyanide treatment of the tailing extracted a further 32·4% of the silver, making a total extraction of 62·3%. The concentrate, however, is too low grade to be considered a commercial product.

Flotation after sulphidization with various reagents was now tried. Sulphuretted hydrogen gas, sodium sulphide, calcium polysulphide all are effective. Either serves the purpose, but most of the work was done with sodium sulphide (fused, carrying about 60% Na_2S) on account of its being available in a convenient form. At El Favor calcium polysulphide made locally would probably prove the more economical.

It was early learned that the silver rebellious to cyanide was equally rebellious to flotation. That is to say, flotation as developed up to the present time appears to have no effect on the rebellious silver, recovering only the silver mineral soluble in cyanide. This is certainly unfortunate, as were it the other way round the manganese silver problem would be solved by flotation of the cyanide tailing or *vice versa*. A few tests, however, demonstrated that the flotation concentrate yields its silver to cyanide, whereas the silver remaining after flotation is insoluble in cyanide. Furthermore, flotation after cyanide treatment fails to yield a silver bearing concentrate. It would appear therefore that while the results of flotation experiments are especially interesting at this time on account of the scarcity and high price of cyanide and zinc, they do not offer a solution of the manganese silver problem as such.

The sodium sulphide used for sulphidizing the ore has a double action on the silver. The soluble silver is sulphidized and rendered floatable, and in addition a part of the rebellious silver is altered to a form soluble in cyanide. This recalls the Henry E. Woods report to the effect that sodium sulphide reduces the manganese and frees the silver to cyanide. Their observation as to its erratic behaviour is also confirmed in that while a 10% to 20% addition extraction is consistently maintained, I have not been able up to date to better this result, even by the use of a large excess of the reagent.

Another interesting point has been developed in that by concentration of the tailing from flotation plus cyaniding, an additional 10% of the silver in the ore can be recovered in the form of a concentrate of commercial value. As high as 100 oz. silver to the ton has been attained. That is to say, a sample that had been properly sulphidized and floated in the Janney machine, and the tailing from this cyanided, would yield a further 10% extraction by table concentration of the cyanide tailing. It is to be noted that this is just what is normally extracted on the Wilfley tables in the El Favor mill, and it seems very likely that the operation of the Wilfleys in conjunction with a flotation unit would increase the recovery by that amount.

The sulphidization of the ore is accomplished by simply agitating in a weak solution of the alkaline sulphide. At the outset this was done in a bottle previous to flotation, but the time was gradually shortened to a point where the operation was carried out right in the flotation machine. The results of a representative experiment along the lines indicated are as follows:—

200 gm. of ore ground to 100 mesh, 1 gm. of sodium sulphide, 1,000 cc. water at about 40° C. and 6 drops Pine Tar Oil No. 8 agitated slowly in the Janney machine for five minutes. Machine then filled to the proper level with water (2 litre speeded up and the concentrates skimmed. Three drops additional pine tar oil added during skimming.

The flotation tailing was filtered and washed to remove the excess of sodium sulphide (altered to Na_2SO_4?) and agitated in a 2 litre bottle for 24 hours with a 0·3% solution of potassium cyanide. After removing sample for assay the rest of the pulp was carefully panned.

Assay of head sample 20 oz. silver:—

	Weight.		Assay.	Extraction.	
	gms.	p.c.	ozs. ton.	ozs. ton.	p.c.
Concentrate (float)	11·0	5·5	174·50	9·60	48·5
Flotation tailing..		94·5	10·80		
Ext'd. by Cyanide		—	2·60	2·45	12·4
Cyanide tailing ...		–	8·20		
Gravity concentrt.		2·1	98·00	2·06	10·4
Final tailing		92·4	6·16	5·69	28·7
				19·80	100·0

The total extraction by flotation, plus cyanidation plus concentration is therefore 71·3%.

It will of course be suggested that if we are to use cyanide at all we might as well eliminate the flotation and recover the silver as bullion rather than as concentrate. I am not, however, presenting the above as a feasible process, but simply as the result of laboratory experiments undertaken to learn as much about a rebellious ore as possible.

Some hundreds of flotation tests were made with different oils, different sulphidizers, temperatures, dilutions, etc., etc. A complete discussion of the results would be beyond the scope of this paper.

SUMMARY.

The processes investigated in this research fall naturally into two classes—those requiring dry crushing and those adapted to a wet pulp.

Considered strictly on their merits as metallurgical processes, I should prefer the former, and I am of the opinion that either a chloridizing or a reducing roast, followed by cyaniding, offers an acceptable process for ores of this class. The El Favor mill, however, is arranged for wet crushing, so under anything like equal efficiency a process adapted to wet crushing would have the preference in our case.

The chloridizing roast on these ores is not new and has been successfully operated. The reducing roast is, so far as I am aware, untried on a working scale, but as the volatilization loss would be less than that expected in salt roasting, and might easily be nil, the process has merits that deserve serious consideration.

The low grade of the concentrate obtained by magnetic and electrostatic processes, necessitating local treatment of the concentrate, is a serious disadvantage, and it is questionable whether their apparent advantages would not be more than counterbalanced by the greater complexity of plant required. Almost certainly this would be the case in any but a large installation.

The Hamilton process, modified by the use of additional reagents, appeals strongly on account of the high extractions obtained. It is in fact the only process tried that can be said to offer a real solution of the trouble —the others are makeshifts.

In the practical application of this process there seems to be no way of avoiding a double treatment, the first working in acid solution and the second in alkaline. A solvent for silver that would not be destroyed by acids or that would be so inexpensive that a considerable loss could be allowed, would solve the problem, but I know of none.

The loss of sulphur in the process is an unknown factor, and until the result of commercial operation over a period of at least weeks is made known, it is likely to remain so.

The flotation process does not profess to solve the difficulty, but possesses many features that are attractive at the present time. Even if the little brown brother in Mexico would compose his affairs, it is a question whether we could count on securing a steady supply of cyanide. Further, at the present prices of cyanide and zinc it appears that the cost of realizing the silver in the high grade concentrate produced might well be less than the cost of producing silver bars at the mine by cyaniding. A flotation unit is a comparatively inexpensive machine and could be put in at the El Favor mill without material alteration of the flow sheet. The process could indeed be tried on a commercial scale at less expense than would be incurred by a similar test of any of the other processes proposed.

Notices and Abstracts of Articles and Papers.

METALLURGY.

On the Transformations of Pure Iron.—The present communication is composed for the most part of extracts from letters to Sir Robert Hadfield, and deals with the nature of the molecular constitution of pure iron.

It is believed by a large school of metallurgists that the A_2 transformation can be satisfactorily explained without assuming allotropic change. The A_3 transformation, on the other hand, is generally regarded as involving allotropy. But it appears that varied views are taken as to what really constitutes an allotropic change, and until some definite conception of this term is adopted—some criterion which shall decide whether a given transformation does or does not involve allotropy it seems that no definite advance can be made, for every argument brought forward by one school can always be shown to be inconclusive by another school whose fundamental conceptions are different. One of the most exacting definitions of allotropy is that given by Benedicks. The criterion is one of mathematical discontinuity, *i.e.*, two ordinates for the same abscissa. This definition is admirable from a theoretical point of view, but it appears that no experimental work is ever precise enough to approach the demands of such a definition, and, therefore, it is always open for an opponent to lodge complaints.

A definition which I believe to be satisfactory, and which can also be subjected to direct experimental test, is the following:—

Each different atomic structure of the molecule is an allotropic modification. It is essential, however, to explain the word 'different' used here. In some experiments on 'The Influence of Molecular Constitution and Temperature on Magnetic Susceptibility,' I have been frequently been led to the conclusion that the molecules of crystalline, and even of liquid, substances are in a distorted state. This distortion is always very slight and is due to the action of restraining forces exerted by neighbouring molecules on each molecule of the material medium. It is clear, therefore, that the configuration of a molecule in a crystalline medium is slightly different from that of a molecule of the same substance in the liquid. If the mutual influences of the molecules were withdrawn, the molecules of both states would alter their configurations slightly and would become identical. Such a relationship between the molecules is of the nature I have previously called 'crystalline grouping' and the distorted condition of the molecule is not to be regarded on the above definition as indicating allotropy. If, indeed, allotropy were determined in this way, then every degree of association would imply a new allotropic form, the number of which would be infinite for each substance throughout a finite interval of temperature and 'allotropy' would be a useless term.

But if the molecule of the crystalline structure, on *withdrawal of the restraining forces*, differ in configuration from a free molecule which has originated in some other way (say by an independent chemical or physical process), either as regards the integral number of atoms in the molecule or the relative distribution of those atoms, even if their number remains the same, then the substance exhibits allotropy. As examples we may take the oxygen to ozone transformation and the many types of isomers known to organic chemistry. Not only has an allotropic modification characteristic physical properties, but, to some extent, characteristic chemical properties too. The constitutional formulæ of modern chemistry are founded on the assumption that the properties of a substance are determined by the nature, number, and mutual dispositions of the atoms within the molecule.

Now the crystalline forms of allotropic modifications will be characteristic, for the space lattice will be conditioned by the configuration of the molecule which determines the restraining forces. On the other hand it has been shown that *molecules of exactly the same configuration* may be packed into quite distinct crystalline aggregates, of different degrees of stability, so that a difference of crystalline symmetry does not necessarily imply allotropy in the sense defined above.

It should be pointed out that this definition is not specially designed to meet magnetic considerations; it is consistent with the recognised chemical view. We must distinguish between the forces holding the molecules in position in the crystalline structure and those holding the atoms together in the molecule, and if the latter forces are large compared with the former (thermo-chemical evidence that this is so will be given later), then the preservation of molecular identity, and hence the rarity of allotropic change, will not be a surprising phenomenon.

The above remarks lead us to a criterion by which the nature of the so-called β to γ transformation may be discussed. Weiss has shown that the magnetic properties of β and γ iron can be interpreted in terms of a simple atomic constitution of the iron molecule, and the point of importance for us is that the iron molecule consists of two atoms in the temperature intervals of stability of the β and γ forms, and, therefore, through the tranformation from paramagnetic γ iron to ferro-magnetic β iron there is no change in the integral number of atoms constituting the iron molecule. Weiss's work shows that each state of iron provides a measure of the constant of Curie (C), the parameter of the hyperbolæ representing the variation of specific susceptibility as a function of the absolute temperature. In conclusion, he states:

"Le passage du fer β au fer γ qui correspond à la perte des actions magnétiques mutuelles sans variation du nombre des atomes de la molécule reste à expliquer, mais la concordance des diverses valeurs de C ne peut etre due au hasard."

Hence in so far as the integral number of atoms in the molecule is concerned we cannot regard A as an allotropic change-point.

It is interesting to note that Barlow and Pope have pointed out that those elements which crystallise in forms of high symmetry are the ones which show the least tendency to form allotropic modifications. Iron is known to crystallise throughout the β and γ ranges in cubic system. Further, Retgers has shown that the higher the crystalline symmetry of a particular element the smaller, as a rule, is the number of atoms contained in the molecule. These points are consistent, and are in favour of absence of allotropy in iron.

The simple atomic constitution of the iron molecule makes it improbable that changes of physical properties of iron can be due to a rearrangement of the atoms in the molecule. It is conceivable that the two atoms may be slightly displaced relative to one another as the transformation points are passed, but we cannot regard the resulting iron molecule as a distinct type possessing a new set of properties. Moreover, from a magnetic point of view, assuming that magnetism is to be ascribed to polar molecules, however this polarity may originate, the appearance of ferro-magnetism on cooling could not be explained on such a view. Ferro-magnetism demands inter-molecular forces—the forces of crystallisation—although no one doubts that inter-molecular forces and intra-molecular forces are inseparable, and that a small change in the latter may accompany and indeed is essential in a re-grouping of the molecules. If we imagine the inter-molecular restraining forces abstracted, then the molecules of the β and γ forms of iron would be absolutely identical.

If there is no abrupt change of the atomic constitution of the iron molecule, then changes of the properties of pure iron such as occur at A must be ascribed to a change of crystalline grouping of the molecules. This change must be of such a nature that the crystalline symmetry is not affected on passing A; a change of the closeness of packing of the molecules is all that is required. If the cooling through A is accompanied by a closer grouping of the molecules in the direction which is characteristic for each crystal of spontaneous magnetisation, there will be no change of crystalline symmetry, while the increased interaction between the molecules will give rise to spontaneous magnetisation. The variation of molecular distances in the directions perpendicular to that of spontaneous magnetisation for an individual crystal is of small importance from a magnetic point of view, for each molecule is mainly constrained by the molecule in front and the one behind in the direction of its magnetic axis. Thus this interpretation is not necessarily inconsistent with known magneto-striction data or with determinations of thermal expansion (linear or volume) of a *mass* of iron crystals.

If there is a change of molecular arrangement at A, then on passing this point there will be a thermal effect determined by the difference between the internal potential energies above and below A. There may be an accompanying molecular distortion, but this will be slight, and (as already pointed out) cannot be regarded as implying allotropy. The thermal energy evolved on cooling through A is just the heat of transformation from a more open to a closer packed cubic system, as described above, with probably a small contribution from intra-molecular adjustment *resulting from the change of packing*. As already pointed out, these two parts of the thermal evolution are inseparable, but the existence of the second part does not justify the existence of a new type of iron molecule. Accompanying the re-grouping, the iron molecule takes up a slightly distorted appearance of the iron molecule on the other side of A. Under pressure we should no doubt get a slightly different re-grouping of the molecules, and, as a consequence, a slight variation of the atomic separation in the molecule. This variation of separation will be different for different pressures, and, therefore, like the phenomenon of association mentioned on p. 351, cannot be regarded as implying allotropic change.

It is known that the transformations from ozone to oxygen and from white phosphorus to red are exothermic. The thermal evolutions accompanying allotropic and isomeric changes are comparable with the heats of formation of chemical compounds, and are in general large compared with those involved in the passage from the liquid to the crystalline state or from one crystalline state to another. The following are some values of the thermal evolution accompanying known allotropic and isomeric changes :—

Allotropic

96 gm. ozone = 96 gm. oxygen + 59,200 gr. cals.
31 gm. yellow phosphorus = 31 gm. red phosphorus + 21,000 gr. cals.

Isomeric

78 gm. dipropargyl = 78 gm. benzene + 100,000 gr. cals.

58 gm. allyl alcohol = 58 gm. acetone + 18,600 gr. cals. = 58 gm. propaldehyde + 22,600 gr. cals.

With these may be compared the following values of the latent heats of fusion of some elements :—

Element.	Latent Heat (gr. cals.).
Bismuth	13
Cadmium	14
Lead	5
Silver	22
Tin	14
Zinc	28
Gallium	19
Phosphorus	5

These latter values are comparable with the thermal evolution during the transformations of pure iron. From the recalescence curves given by Dr. Arnold for this substance the rise of temperature is largest for the A transformation point, and is approximately 14° C. Hence, taking the specific heat of iron as 0·1, the thermal evolution at A is 1·4 gr. cals. This small thermal evolution favours the view expressed above that the A transition involves a molecular re-grouping, similar to that which occurs in the ordinary process of crystallization, rather than a re-building of the internal structure of the molecule. Therefore from the thermal point of view also, allotropic change, as defined in the present paper, appears to be absent at A.

The co-existence of thermal expansion and thermal evolution on cooling through A cannot be advanced as an objection to the views developed above, for the same phenomena accompany one another during the transition from water to ice.

I am much indebted to Sir Robert Hadfield, first for suggesting the application of the results of my earlier work to the transformation-points of iron, and second for the encouragement he has given me throughout the whole of our correspondence."—A. F. OXLEY, M.A., D.Sc., Transactions Faraday Society. —*Cassier's Engineering Monthly*, Dec., 1915, p. 351. (J. E. T.)

NEW THEORIES OF FLOTATION.—"The principal patentees and the metallurgists using flotation in practice have ventured little in public as to the underlying theories of flotation. This is not because the matter has not been investigated, but doubtless is due to the feeling that no wholly satisfactory theory had yet been developed. In the United States the subject has attracted new interest of late. Mr. C. T. Durrell, a practising engineer, proposed in the *Mining and Scientific Press* for September 18, a theory based upon the affinity of 'nascent' gases in the solutions for 'occluded' gases in the particles floated. Stated briefly, he suggests that these two gases meet and collect on the surface of the solid involved until a bubble is formed which is sufficiently large to float the particle. Oliver C. Ralston, of the staff of the Experimental Station maintained at Salt Lake City by the co-operation of the United States Bureau of Mines and the University of Utah, criticises this theory in the *Mining and Scientific Press* of October 23. He holds it unproved and unnecessary, and states that an adequate working hypothesis can be built up on the known facts and stated either in terms of inter-facial tensions, or in terms of the electrical charges of suspended particles. The first, which goes back to Clerk Maxwell's work, is the more commonly accepted hypothesis. The electrical theory seems to have been developed simultaneously and independently at the Utah Experiment Station, at the Mellon Institute at Pittsburgh, and at the Case School of Applied Science at Cleveland. Mr. Ralston, in the *Mining and Scientific Press* of October 23 last, presents his preliminary results so that other investigators may be able to use them in further research. The work at the Mellon Institute was conducted by R. C. Bacon and J. M. Callow, and Mr. Callow gives a brief statement of the theory in his paper read before the Utah section of the American Institute in October and printed in the December *Bulletin*. At the Case School, where Charles H. Fulton occupies the chair of metallurgy, studies of flotation have been in hand for the past year or more, and in the *Mining and Scientific Press* for November 27 and December 11, Thomas M. Bains, Jr., presents the results. Mr. Callow states the theory briefly as follows: 'It is a scientific fact that when a solid particle is suspended in water, the water will form around the particle a contact film which generally possesses an electric charge, the amount and polarity depending upon the nature of the surface of the particle and the electrolyte in which it is suspended. The presence of these charges can be demonstrated by the fact that the particles possessing them will migrate when placed in an electrical field. It has been demonstrated that flotable particles have charges of one polarity (positive) and that non-flotable particles have charges of the opposite polarity (negative); that the froth is charged negatively and so attracts the positively charged or flotable minerals, and repels the negatively charged or non-flotable ones. It is this, it is believed, that causes the floatable minerals, galena, sphalerite, etc., to adhere to the froth, and the gangue minerals, silica, etc., to remain in the liquid where they can be discharged as tailing.'

Mr. Bains adds many details and summarizes as follows: 1. Ores containing valuable minerals or metals that are good conductors are the only likely ones that are suitable for flotation. 2. To buoy these conductors, it is necessary to supply enough electrified bubbles from below to float particles of the conductors that are attracted; hence the smaller the bubble, the better the result, the amount of gas being the same. 3. Some dielectric fluid is necessary to cover the conductor or the bubble to prevent the dissipation of the electric charge. The thinner the film of dielectric and the greater its dielectric strength, the greater the effective attractive force and the more permanent will be the froth. 4. Some material must be added to the water to increase its conductivity, to obtain a clean concentrate; acids in small quantity are now used. He also suggests that since the electrification of minerals varies with different acids and also with different strengths, preferential flotation can be accomplished as for example in separating blende, galena, pyrite, and quartz as follows: 'Add dilute sulphuric acid and pan off the blende; then add dilute nitric acid and pan off the galena; then add concentrated sulphuric or nitric acid, which attacks the pyrite so it may be panned off.' The same result may be accomplished with 'nitric acid above, varying the strength; with sulphuric acid, by use of a 'robbing' action; or by use of hydrochloric and other reagents that attack one or another of the minerals more strongly than another.' He makes another statement that, if the electric theory be accepted, has a bearing on the disputed question whether in flotation the phenomenon as essentially different when the oil or frothing agent is reduced to the extremely small amounts specified in Minerals Separation patents. It is that 'the sulphides are positively charged by friction, while the frothing agent and air are charged negatively. The oil surrounds the sulphides, but the film is so thin that the negatively charged bubble is attracted by the positively charged sulphide. If the film of oil is too thick, the attraction between the sulphide and bubble is too feeble, and flotation fails.' Mr. Ralston considers that 'the inter-facial tension and the charge on the inter-facial film are two different physical properties of one and the same thing,' and states that 'No one can claim that electrical charges carry the whole explanation of flotation, nor can it be stated that it is merely a balancing or inter-facial tensions.' The importance of his work, which extends also to settlement of slimes and similar phenomena, is that it presents at least strong probability that the laws of colloidal chemistry are applicable to ore slimes or 'coarse suspension colloids' as he calls them. If indeed the analogy be sufficiently close, even if it be nothing more, progress in flotation may be immensely accelerated by carrying over into this field what is now known of colloids and electrostatics."—*The Mining Magazine*, Jan., 1916, p. 47. (J. E. T.)

CYANIDE TREATMENT OF FLOTATION CONCENTRATE.—"Extensive application of cyaniding to silicious ores some years since upset the balance at the smelters and checked the decrease in rates on sulphide ores. This in turn caused the cyaniders to search for methods, which proved widely applicable, of local treatment of concentrates. Flotation is now bringing in a new and large supply of concentrates, and it is a serious question how far cyaniding can be applied. This matter has been under study in the Butters laboratory, and in the *Mining and Scientific Press* for November 20, Charles Butters and J. E. Clennell present results of work on flotation concentrate from the San Sebastian mine in Salvador.

'The difficulties attending the treatment of concentrate by cyanide,' say these authors, 'are well known. The process of concentration collects in a small bulk not only the valuable constituents of the ore but also those substances that act as cyanicides, or which are readily converted by oxidation or otherwise into cyanicides, so that their influence, per ton of material treated, is greater than would be the case with the unconcentrated ore. Heavy minerals such as the sulphides of iron, copper, lead, arsenic, antimony, zinc, and double sulphides such as mispickel, proustite, pyrargyrite, and bornite, naturally tend to accumulate in the concentrate. If some interval elapses between the formation of this concentrate and its treatment, oxidation may take place, with formation of sulphates, arsenates, and antimoniates, which are still more detrimental to cyanide treatment than the original minerals. These difficulties have been wholly or partly overcome by the adoption of modifications in the treatment, such as preliminary water, acid, or alkali washing, roasting, fine grinding, the use of special solvents, such as bromocyanide, and prolonged contact of the material with cyanide, extending in some cases to over a month.

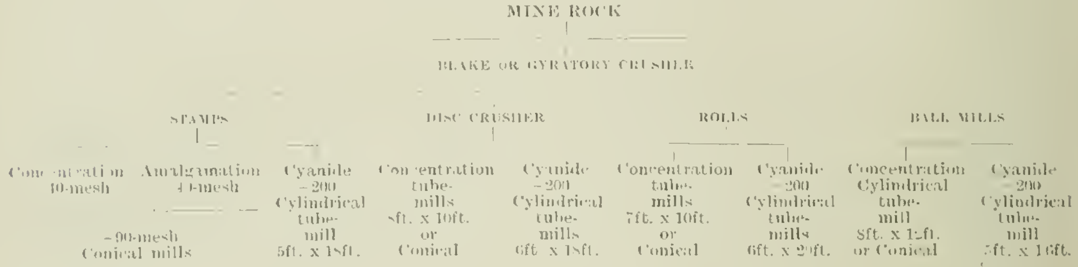
'In the case of concentrate produced by flotation, the minerals composing the product are substantially the same as those obtained by gravity concentration, consisting of the sulphides and double sulphides of the heavy metals, and it is to be expected that the same difficulties will be encountered in their treatment. But as the concentrate also contains a considerable part of the oil, tar, or other flotation agent, the presence of this foreign matter must be taken into account. In some cases, this circumstance introduces an additional difficulty. A part of this organic matter is soluble in the cyanide or alkali used in the process, and the solution so formed may be capable of absorbing oxygen. The effect produced by carbonaceous matter in precipating gold and silver previously dissolved by cyanide is well known and has been a source of much trouble in many localities. Some of the constituents of this matter are not easily eliminated and appear to resist oxidation even at a high temperature; roasting under ordinary conditions does not completely remove the carbon; it is probable that a portion derived from tar remains in the graphitic form, capable of acting as a precipitant for gold or silver.'

Elaborate tables are presented showing the effect of various modifications of direct treatment as applied to the San Sebastian concentrate. It was found that an extraction of 98% could be obtained from the flotation concentrate after roasting, water washing to leach out the sulphates, and cyaniding. Cyaniding the raw ore proved unsatisfactory."—C. BUTTERS and J. E. CLENNELL, *Mining and Scientific Press*, Nov. 20, 1915.—*The Mining Magazine*, Jan., 1916, p. 51. (J. E. T.)

THE YEAR'S CHANGES IN CRUSHING AND GRINDING.—"The year 1915 has closed, and all accounts must be audited and business shaped for the following year. In crushing and grinding machinery a certain type gains or loses popularity, may be by reason of good advertising, by successful installations, or by some big company adopting that type of machine. One cannot look about at the present time without noticing the popularity of the tube mill, either in the form of a ball mill, a long cylindrical mill, a short tube of big diameter and short length, the marathon mill, or of the conical mill, with its big diameter and sizing cone. The need of finer grinding, whether for concentration, amalgamation, cyaniding or flotation, has made it necessary that we have a machine that covers a wider range of reduction than that formerly possible, so the tube mill has been lengthened, and shortened, and expanded, and contracted until we have a choice of many sizes to suit the particular work necessary. Ball mills are made with screens on the surface of the cylinder, and without screens, operating like the usual tube mill, by displacement. The 5-ft. cylindrical mill was thought to be the ultimate diameter a few years ago, now we have them 8 ft. in diameter while the conical still leads the way in increasing diameter, by giving us a 10-ft. mill. With the increase in diameter, the tube mill has been shortened, for a forced feed with a return of oversize is economically right, and a short mill is particularly adapted for this class of work. Costs have been lowered by studying the various factors that promote economy, so that we have grinding in these large diameter tube mills at as low as 7 cts. per ton of ore ground.

The following chart shows the usefulness of the tube mill in stage grinding.

Flowsheet Showing the Usefulness of the Tube Mill in Stage Grinding.


MINE ROCK
BLAKE OR GYRATORY CRUSHER
STAMPS
DISC CRUSHER
ROLLS
BALL MILLS
Concentration 40-mesh
Amalgamation 40-mesh
-90-mesh Conical mills
Cyanide -200 Cylindrical tube-mill 5ft. x 18ft.
Concentration tube-mills 8ft. x 10ft. or Conical
Cyanide -200 Cylindrical tube-mills 6ft. x 18ft.
Concentration tube-mills 7ft. x 10ft. or Conical
Cyanide -200 Cylindrical tube-mills 6ft. x 20ft.
Concentration Cylindrical tube-mill 8ft. x 12ft. or Conical
Cyanide -200 Cylindrical tube-mill 5ft. x 16ft.

Our primary crusher is a Blake or a gyratory, both equally effective. Our secondary crushers may be stamps, disc crushers, rolls or ball mills. If our object is amalgamating with or without concentrating, and we desire nothing finer than 40 mesh, the stamps alone are sufficient. If we desire a 90 mesh product for amalgamating or concentration, we may regrind with a conical mill, or a cylindrical tube mill of short length and big diameter, in a closed circuit with a classifier. If we desire a 200 mesh reduction for cyanide treatment, we must use a cylindrical tube mill, in circuit, with a classifier.

When we use a disc crusher for secondary reduction for concentrating ore, it must be followed by a conical or a tube mill of big diameter and short length, and when for the production of a slime for cyanide treatment, by the cylindrical tube mill.

If we have rolls as secondary crushers, and the object is concentrating, they may be followed by the conical mill, a tube mill of medium diameter and short length, and if for 200 reduction, by the cylindrical tube mill.

If ball mills are used as secondary crushers, they may be able to deliver a product sufficiently fine for concentration, but if not, they must be followed as in the last instance, by a conical or cylindrical mill, and if for an all sliming process, by the cylindrical tube mill.

From a summing up of my ideas on the subject certain facts may be gathered: First. The stamp mill is still with us for amalgamating and a medium size product, and in combination with the cylindrical tube mill, for cyanide treatment of a slime. Second. The popularity of the conical mill for a product up to 90 mesh, in competition with a cylindrical tube mill of big diameter and short length in circuit with a classifier, and third, the deserved popularity of the cylindrical tube mill with varying diameter and length according to the size of the feed."—Algernon del Mar.—*Mining and Engineering World*, Jan. 1, 1916, p. 50. (H. R. A.)

Warming Cyanide Solutions.—"At the December meeting of the Institution of Mining and Metallurgy, E. A. Wraight presented a paper describing experiments made with the object of ascertaining whether the rate of dissolution of gold by means of cyanide could be increased by warming the solution. The published records of similar investigations are limited, and the results obtained are either vaguely interpreted, or attributable to other causes. Mr. Wraight first undertook a series of researches in which the pulp was agitated and heated by steam. His general results showed that though rather more gold was dissolved during the first hour by hot solution, the efficiencies of the hot and cold solutions were much the same afterward. His individual results were naturally governed by the nature of the particular ores treated. He subsequently conducted another series of experiments in which the agitation was effected by means of hot air. In this case he obtained striking results, for the rate of dissolution of the gold was substantially increased. His conclusion is that the oxygen effect in the cyanide reaction is increased when the oxygen is heated."—E. A. Wraight, Proceedings Institution of Mining and Metallurgy.—*The Mining Magazine*, Jan., 1916, p. 54. (J. E. T.)

The Sound Ingot Problem.—"Undoubtedly the big-end-up arrangement of moulds is best from the point of view of obtaining sound steel, because the large top area compensates automatically for irregularities in steel temperature and in teeming practice. Many mills are, however, equipped for handling 'big-end-down' ingots, and in a paper read a few weeks ago in San Francisco, E. Gathman dealt with means whereby the desirable lag in cooling at the top of ingots could be obtained without any extensive change in equipment.

Some metallurgists deliberately prefer 'open' ingots of certain steels, *i.e.*, ingots honeycombed with blowholes and hence having relatively little true 'piping.' The argument is that such ingots will weld up solid during rolling or forging because the surfaces of the blowholes are not oxidised. Actually all heats are more or less oxidised unless made or finished in the electric furnace, and the line of demarcation between harmful and harmless (?)

blowholes is difficult to define. It is much better practice to degasify steel thoroughly by use of ferro-silicon, aluminium, titanium, or other of the relatively cheap deoxidisers available, thus practically eliminating blowholes and the segregation caused by them, and obtaining ingots with a well-defined shrinkage cavity at the upper end.

To reduce the shrinkage cavity area and hence obtain sound blooms with minimum waste in cropping, an ample supply of liquid steel is required in the top strata of the ingot to fill in shrinkage which occurs as the lowers layers become solid. This lag in top cooling may be obtained by using a big-end-up mould; or it may be obtained in a big-end-down mould by making the bottom walls of the latter much thicker than the upper walls. The limited heat capacity of the thin neck walls may be supplemented by a sink-head or sleeve of poorly conducting material hung freely inside the mould cavity. The net effect is to give the lower 70% or 80%, of the mould a much greater heat-absorbing capacity than the remainder of the mould, and, at the same time, to retain plenty of liquid metal to compensate for contraction with a minimum of piping. The crop necessary to eliminate pipe and segregation can be reduced by this means to 10% or 12% of the cold ingot.

It is good practice to strip the mould from the ingot before the central portions of the latter are entirely solidified and to place it at once in a soaking pit, so that the temperature may be equalised and the final 'feeding' of shrinkage occur. When the steel is entirely set, *but not before*, it may be rolled whilst the interior is hotter and more plastic than the exterior. Rolling from butt to head when reducing ingots to blooms materially reduces cropping loss."—E. Gothman. *The Engineering Review*, Feb. 15, 1916, p. 270. (J. E. T.)

Clay in Ore-Dressing and Cyaniding.—At the December meeting of the Institution of Mining and Metallurgy, a paper was presented by A. W. Allen containing a record of all information and theories relating to the effect of colloidal clay on ore dressing and cyaniding operations. He discusses the phenomena of absorption and adsorption, as applied to the explanation of the impossibility of removing gold solution from clayey slime; he inquires into the causes that make weathered clay slime more difficult to treat than freshly mined material, and into the reasons why milling a clayey ore in cyanide solution does not give such satisfactory results as when the milling is done in alkaline water. His general conclusions are that the main losses of gold are due to absorption and not adsorption. Mr. Allen's bibliography and discussion of the views of various writers make his paper valuable."—A. W. Allen, Proceedings Institution of Mining and Metallurgy.—*The Mining Magazine*, Jan., 1916, p. 53. (J. E. T.)

Refining of Precipitated Gold (Cyanide Process).—"Bullion of higher purity can be obtained if the usual acid treatment of cyanide precipitates is supplemented by treatment with acid and bichromate. After treatment with acid as usual, the solution is separated and the residual slime is mixed with a quantity of water equal to about five times its dry weight. The mixture is heated and continuously agitated, and sulphuric acid and potassium bichromate (4 lb. of 66°, acid to 1 lb. of bichromate) are added, in small portions at a time, until an excess of chromic acid persists for 3 or 4 mins. The solution is then separated and the residual slime well washed. The slime settles well, and when dried and smelted in a clay crucible with borax glass and a small quantity of nitre, yields bullion practically free from zinc, lead, and copper."—H. T. Durant, *Eng. and Min. J.*, 1915, *100*, 523-524.—*Journ. Soc. Chem. Ind.*, Oct. 30, 1915, p. 1056. (J. W.)

Stellite.—"Stellite is the name given to an alloy, or group of alloys, used for high-speed cutting tools, and consisting essentially of cobalt and chromium with additions of tungsten, molybdenum, or both. The alloy has a colour between those of steel and silver and is unchanged by exposure to dry or moist air at temperatures below a dull red heat. It is very hard and resistant to abrasion, cannot be forged (as it retains its hardness at a full red heat), and can only be reduced to the desired form by casting into bars and grinding the latter to a cutting edge. As showing the efficiency and durability of the material, two examples are given in each of which a tool $2\frac{1}{2}$ in. long and $\frac{3}{8}$ in. square in cross-section was used on cast iron pistons: in the first, 14,000 grooves were cut in pistons $3\frac{1}{2}$—$4\frac{3}{8}$ in. in diameter, while in the second over 8,000 lb. of metal was turned off, before the tool became too short for further use."—E. Haynes. *Amer. Inst. of Metals*, Sept, 1915.—*Journ. Soc. Chem. Ind.*, Oct. 30, 1915, p. 1058. (J. A. W.)

Oils and Other Reagents in Ore Flotation.
"There are probably now 200 ore flotation plants in active operation in the United States. Of the oils used mainly for their froth producing properties the most successful are pine oil, eucalyptus oil, cresol, turpentine, and essential oils; kerosene, gasoline, and a mixture of 1 part of castor oil and 4 parts of kerosene have also been used with good results. Mineral oils and tar oils are used as collecting oils, *i.e.*, mainly on account of their selective action on sulphide minerals; in general wood creosote and oils from wood distillation give the best results with galena and zinciferous minerals, whilst coal tar products are more satisfactory in the case of copper-bearing minerals. Oleic acid has a marked power of separating silica by flotation. In experiments on an ore (60-mesh) from the Joplin district, containing pyrite and galena in a calcareous gangue, satisfactory results were obtained with a mixture of 5 parts of wood creosote, 2 of pine oil, and 0·5 part of coal tar; part of the pine oil could be replaced by soap solution. The effect of temperature was negligible, and the results were not improved by addition of sulphuric acid. Addition of alkali sulphate or ferric sulphate promoted the production of clean concentrates, and potassium bichromate "deadened" the galena, thus permitting a preferential flotation of the pyrite. Successful flotation could not be achieved in presence of ferrous sulphate or copper sulphate."—R. J. Anderson, *Met. and Chem. Eng.*, 1916, *14*, 135-137. *Journ. Soc. Chem. Ind.*, March 15, 1916, p. 312. (J. A. W.)

Abstracts of Patent Applications.

(C.) 188/15. James Peter Cloete. Improvements in percussion hand drills and the like. 9.8.15.

This application refers to a percussion hand drill comprising a drill sharpened at both ends, to which weight is attached at any convenient point, the drill being used as a jumper, the weight serving to give force to the blow.

(C.) 190/15. Andrew Frederick Crosse (1), Frank Campbell Dunat. (2). An improved process for the treatment of crushed auriferous ore products. 9.8.15.

This application relates to an improved process for the treatment of auriferous stibnitic ores with a solution of free hydrocyanic acid in conjunction with alkaline bicarbonate.

(C.) 246/15. John Penhale. Improvements in the treatment of zinc-gold slimes. 30.9.15.

This application relates to the treatment of zinc-gold-slimes recovered in the ordinary cyanide process. The main feature of the process is the recovery of the zinc which is now generally being run to waste as zinc sulphate.

The process consists in distilling off the zinc after the zinc-gold-slimes have been mixed with a specified quantity of litharge and carbonaceous matter.

(C.) 73/16. John Thomas Hird (1), Sydney Joseph Crowther Wilkinson. (2). Improvements in shaft rollers, idlers and the like. 16.3.16.

This application relates to improvements in shaft rollers and the like, and refers to a previous Patent —No. 130/15 by Wilkinson, for a method of lubrication from centre of spindle.

The principal claim is for conical outside rollers in a set of three, the centre one being of the usual V section and terminating at the small end of the cone on the outer rollers.

(C.) 124/16. Edward Royal Holden. Improvements in the treatment or ores. 23.5.16.

This application relates to a combined method of ore-treatment with solvents, by agitation, fractional classification and electrical precipitation and amalgamation. The apparatus consists of a deep vat, provided with a central shaft, a number of agitation-blades, a number of outlets for the various products in suspension, anodes attached to agitation blades and a copper cathode lining to the vat, which is amalgamated with mercury. The method of operation consists in agitation of the ore with suitable solvent at such speed as will separate the ore into strata of different specific gravity, and after sufficient time has elapsed for the solvent to act to draw off the different strata successively, to settlement vats, the lowest stratum being sent to a special settlement vat for further treatment.

(C.) 125/16. Edward Royal Holden. Improvements in and relating to apparatus for separating ores. 23.5.16.

This application is for an apparatus designed to separate crushed ore into its various constituents, and consists of a U shaped conduit, the horizontal member of which is provided with an agitator of helically disposed blades operating above a shallow inclined mercury bath. The inlet tube is provided with pressure water to maintain a constant level in both limbs, and the outlet, or sorting column, is also provided with pressure water and a collecting vessel at the base of the column. The suggested method of using, is to pass, repeatedly, the crushed ore through the apparatus, adjusting the pressure in the sorting column to suit the specific gravity of the mineral sought.

(C.) 130/16. David Ewart Rennie. Improvements in rope rollers. 26.5.16

This application relates to a form of roller for incline shafts or rope haulages.

The claims made include :—

A frame made of plate with the ends bent up to take the ends of the spindle which are made square, one end fitting into a square hole in one end of the frame and the other into an open topped slot in the other end of the frame.

Outside the slotted end of the frame a rivet is inserted with the head projecting, it is claimed that this will prevent the spindle being lifted out of place should the rope get over the end of the roller.

(C.) 128/16. Arthur Edwin Leigh Scanes (1), The British Westinghouse Electric and Manufacturing Company, Limited. Improvements in or relating to pumps or compressors. 23.5.16.

This application relates to air, gas or vapour pumps or compressors of the kind utilising a liquid in the form of a jet or spray or the like as a working medium.

(C.) 132/16 Francis Henry le Sueur. Improvements in devices specially adapted for the use of miners and others, for purifying or removing dust from the air before it is inhaled, and also applicable for inhalation for medicinal and other purposes. 2.6.16.

This device consists of a vat or flask of metal made flat in shape, and of a size to fit an ordinary coat or shirt pocket. The air is drawn into the flask by means of a tube, one end of which is immersed in the water in the bottom of the flask. The air then passes through the water and out through another tube, which passes to the lungs of the user through a respirator.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Hadden, E. L., *to* May Mine, Banket Junction, Rhodesia.
Lea, W., *to* P.O. Box 49, Sabie, Transvaal.
Williams, G. W., *l/o* South Wales; P.O. Box 3404, Johannesburg.

LIBRARY
APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL OF THE Chemical, Metallurgical and Mining Society OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. SEPTEMBER 1916. No. 3

Proceedings AT Ordinary General Meeting, September 16, 1916.

The Ordinary General Meeting of the Society was held in the South African School of Mines Building, Johannesburg, on Saturday, September 16th, 1916, Prof. J. A. Wilkinson (President) in the chair. There were also present:—

19 Members: Messrs. J. Gray, H. A. White, J. Chilton, F. W. Watson, J. Watson, A. McA. Johnston, Dr. J. Moir, Prof. G. H. Stanley, J. E. Thomas, J. R. Williams (Members of Council), R. W. Bennett, H. W. Gill, B. J. Hastings, A. King, P. T. Morrisby, S. Nettleton, S. Newton, J. J. R. Smythe, and T. P. Waites.

9 Associates and Students: Messrs. J. K. Exter, O. A. Gerber, J. Gibson, J. Ingram, R. W. Irwin, D. W. Pugh, T. L. Thorne, H. Ward, and J. A. Woodburn.

16 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Annual General Meeting, held on Saturday, 24th June, 1916, were confirmed.

ELECTION OF NEW MEMBERS.

Messrs. J. E. Thomas and A. McArthur Johnston were elected to scrutineers, and, after their scrutiny of the ballot papers, the President declared the following gentlemen unanimously elected members:—

Boyes, Reginald Cumming, Great Belingwe Gold Mine, Belingwe, S. Rhodesia. Mine Manager.

Hilton, Harry Clifford, Village Main Reef G.M. Co., Ltd., P.O. Box 1091, Johannesburg. Mine Manager.

Farrell, George Frederick Grice, 95, First Avenue, Melville, Johannesburg. Shift Boss, Ferreira Deep, Ltd.

Johnson, John Hayward, Roodepoort United Main Reef G.M. Co., Ltd., P.O. Box 115, Roodepoort. Cyanide Manager.

Mann, James Dunloe, Porges Randfontein G.M., Co., P.O. Box 146, Randfontein. Reduction Manager.

Orenstein, Alexander Jeremiah, M.D., M.R.C.S., L.R.C.P., Rand Mines, Ltd., P.O. Box 1056, Johannesburg. Sanitarian.

Pearce, John William, P.O. Box 5778, Johannesburg. Mine Manager.

It was announced that the following Associates and Student had been admitted since the last meeting:—

Dalrymple, James Livingstone, New Modderfontein G.M. Co., Ltd., P.O. Box 25, Benoni. Mill Shift Leader.

Wilson, George Caldwell, 50, Plein Street, Johannesburg. Metallurgist.

Exter, Julius Karl, S.A. School of Mines and Technology,, P.O. Box 1176, Johannesburg. Student.

ROLL OF HONOUR.

The President: It is with very deep regret that I have to announce the deaths of the following:—

Members.—
Lieut. T. H. Clesham.
Lieut. W. Nicklin.
Associate.—
Lieut. A R. Flynn.
On active service.

And also the following Associates:—
Mr. A. Gifford.
Mr. C. J. van Loon.

I would asy you to pass a vote, in honour of their memory, standing.

All present rose to their feet.

DISTINGUISHED SERVICE.

The President: The Secretary informs me that it has been officially notified that another member of the Society, Lieut. O. D. Filley, has received the Military Cross. It is a great pleasure to make such an announcement, and the gallant Lieutenant has our best wishes for further successes.

There are two of our members on active service, who have rendered distinguished service at the front and with whom the Secretary has been in correspondence. I refer to Capt. G. W. Williams and Major Ralph Stokes, who are both well known to many of us here. We have letters from these gentlemen, which I will now ask the Secretary to read.

The Secretary: You will remember that some months ago we asked if anybody would like to subscribe for comforts to be transmitted to these two gentlemen. The result of this appeal was that four guineas were subscribed, three of which were sent to Major Stokes and one to Capt. Williams. The letters in reply read as follows:—

From Capt. G. W. Williams:—

"I have to thank you for cheque received for the men. I duly bought the cigarettes and gave them to them from the Society.

"We have just emerged from one of the great battles of the 'offensive.'

"At one time the South African Brigade were on our right. They did gloriously, gloriously. I saw the Brigade coming out to rest. They paid a heavy price, but they did splendidly. It made me very proud of my old connection with the I.L.H. and T.M.R.

"But all the troops have done well, though of course some units have done better than others.

"This war is hell, it's organised slaughter, and we are all longing for peace—provided it is such a peace as we shall dictate, and that justice shall be done to those who suffered, and retribution comes to those who are guilty of every foul act that the mind of the Hun could conceive. There's the hell of a debt to pay, and I hope I live to see it paid.

"This is a fair land, a land of open downs, of villages, of tree-bordered streams. It is now a shell-scarred Hell. Villages have vanished as completely as Ecbatana and the "courts where Jamsayd gloried and drank deep." Orchards are gone, woods are merely tangled masses of shattered stumps, chateaux are tumbled piles of crumbled brick, churches are amorphous piles of white stone. I pray that the day may come when Germany shall see her towns laid flat, her orchards and fields but wastes of shell-pocked soil.

"There is no man who has gone into this fighting who has not gone down into Hell, but there are none who survive who do not wish to carry on till justice is done. We have made a graveyard for men of all the Empire by the Picardy streams, but, by God, we've given the Huns hell.

"They lie together here—Home-born and Anzac, South Africans, Maories, Newfoundlanders; horse, foot, and guns; French, British, Indians, Arabs from N. Africa. It is in truth an Imperial burial ground that we have made by these willow-bordered streams.

"I am glad to say that my Company did well and received a high, a very high percentage of honours, and from a casualty point of view we got off very well considering all things.

"Please remember me to everyone I know."

From Major Stokes:—

"I read the words of the Chairman at the April meeting, conveying to me the congratulations of the Society on my recent promotion, with tremendous pleasure. There is nothing so stimulating as the watchfulness of old friends, and nothing more gratifying than favourable remembrances.

"The generous gift of the two members has arrived. There are now many Rand officers in the Tunnelling Service, and I have distributed the money to the sappers by asking nine of these officers to buy smokes for some of their men. The donors may be confident that their gift will reach men who will be deserving and appreciative."

The officers, to whom he distributed the money, were:—

Capt. R. F. J. Weeks, 171 Co., R.E. (Associate); Lieuts. B. B. Briscoe, 172 Co., R.E.; W. G. P. Cobbett, 170 Co., R.E.; E. P. Cowles, 170 Co., R.E. (Associate); H. W. Graham, 185 Co., R.E.; N. W. Graham, 170 Co., R.E.; W. D. Madore, 254 Co., R.E.; E. Pam, 170 Co., R.E. (Past Vice-President), and A. O. Wraith, 182 Co., R.E., all of whom have written gratefully acknowledging the gift.

I have also received a note from Lieut. H. R. Ruggles-Brise, who has also earned the distinction of the Military Cross. He says: "I am at home, still trying to recover from a wound in the leg, but hope very soon to be fit again."

The President: These letters do not call for any comments; I think they speak for themselves. We are grateful to the kind donors of these gifts, who will be pleased to learn of their distribution. We are also glad to hear from our members on active service and I am speaking for you, when I say, that they carry with them our most earnest good wishes for the successes we are sure they will achieve. We also hope that the day will soon be here when we shall welcome them back amongst us safe and sound.

I have another letter from one of our Past Presidents, Mr. Richardson, who says:

"I shall be glad if you will let members know that if any of them, or any of their friends, are coming home with the intention of joining the Royal Engineers,. I may be of some assistance to them in the way of putting them into touch with the right officials, without loss of time, and that they need have no hesitation in enlisting my services in this direction if they think I can be of use. At present I am training a batch of R.E. officers in some special survey work, and so am in more or less close association with the corps."

Should any member know any of our members or associates, who intend to go home, I hope they will bring this information to their notice.

I will now ask our senior Vice-President, Mr. H. A. White, to take charge of the meeting whilst I read my Presidential Address.

RECENT ADVANCES IN CHEMICAL INDUSTRY.

PRESIDENTIAL ADDRESS.

By Prof. J. A. Wilkinson.

The period, through which we are at this moment passing, will be writ large in history. Its titanic international struggles will make it famous, its methods and powers of destruction of men and material will render it notorious. But, notwithstanding the mighty efforts of the nations bent at the moment to a single purpose, it has not been forgotten, that the time is soon coming when the sword will be laid aside, and energy must be concentrated on commercial and industrial progress with all the assistance science and scientific organisation can render.

Those countries, which, in view of their past achievements, may be reckoned as the premier nations of the world, whether engaged in the struggle or not, are making preparations and taking stock of the raw materials of industry within their domains, with the primary object of winning a commercial success, such as will lead to continued national preservation and prosperity. The means proposed to achieve this end, possess no features of novelty to those acquainted with modern scientific method and the numerous instances in which its utility has hitherto been proved for this particular purpose. In fact it can be said to-day without fear of contradiction that nations, which heed not the lesson, must quickly succumb, since the might of science is indispensable for the elevation of mankind. There is no phase or branch of scientific knowledge, which, I venture to state, has assisted and is increasing its capacity to assist in the development and utilisation of national resources, more than the one I have the honour to represent, and for this reason at such a period as the present it should require no apology to transfer your attention for a brief space from cyanide vats and rock drills, to a brief sketch of some of the most notable advances in chemical industry during recent times.

Of the materials used for the construction of apparatus in most branches of chemical industy, iron in some form or other still reigns supreme, but much research has been successfully undertaken to discover alloys of iron, which will meet the requirements of the chemist, more particularly with regard to corrosion. The knowledge of the catalytic influence of carbon on the physical properties of iron resulting in the production of steel, suggested investigations of the effects, which might be possible with other elements; whilst the abundant production of ferro-alloys in the electric furnace by Herault in the first instance and by the powerful reducing action of aluminium on metallic oxides at high temperatures gave the necessary impetus, and at the same time led to the investigation of these effects. The results of this work have rendered possible the development of the automobile industry, and the successful navigation of the air.

But in addition to these triumphs, other problems have been either solved or brought much nearer to final solution. Silicon steels containing a high percentage of silicon are now extensively manufactured owing to their powers of withstanding the action of acids, and those containing a low percentage are utilised in large quantities for electrical purposes, on account of their high resistance. Chromium steels have been used for some time for shoes and dies in stamp mills, and chromium molybdenum iron alloys are distinguished by their resistance to the attack of acids. Chromium iron alloy containing a high percentage of chromium and little or no carbon is stated to resist the action of ozone and the nitric oxides. Nickel alloys containing 22%—23% Ni are non-magnetic, and resist corrosion and rusting; a 30% alloy is used for marine boiler tubes, and a 5% alloy withstands the action of hot caustic soda. Increase in the percentage of nickel decreases the co-efficient of expansion to that of glass and alloys of this character are known in commerce as invar and platinite. More recently Prof. Arnold has discovered an alloy containing 13% Ni, 0·55% C., which is so hard that it cannot be machined, a discovery, which may yet be of some importance here. The economic production of an iron, which will in large measure withstand the action of ordinary atmospheric influences for a prolonged period is still an unsolved problem, but much research has been carried out on the phenomenon of rusting, which brings it much nearer solution, and is at the same time illuminating regarding former experiences. The manganese steels, first discovered by Sir Robert Hadfield, possess such remarkable properties, that the field of their complete utility has not yet been fully explored. One of their many uses, however, is for the cast iron parts of grinding and crushing machines. Vanadium steels have been found useful in making apparatus designed for reactions at high temperatures and pressures, but their high cost has militated somewhat against their commercial use.

Of other materials quartz vessels, which are now manufactured in large quantities by fusion and moulding at high temperatures, have proved more than useful on account of the low co-efficient of expansion (one-tenth that of glass), high melting point and resistance to acids (except H F) of this substance, an invaluable combination of properties.

The economic production of electrical energy in the early eighties vitalised the discoveries of Herault and Hall, namely, the electrolytic preparation of the metal aluminium, which is now used extensively for chemical plant. As its salts are colourless and generally speaking non-poisonous, it is used in the construction of the apparatus required for the preparation of edible substances, such as jams, sugars, milk, etc. It is attacked to a far less degree than any of the other common metals by nitric acid, and for this reason has been widely used, as in the preparation of nitro cotton, the transport of nitric acid in pipe lines and tank steamers, nitrating vessels and drying centrifugals. Buildings for chemical or other industries, in which corrosive gases are evolved, are now made with corrugated aluminium sheets, and large vessels for the preparation of organic products such as dyes, candles, citric acid, formalin, etc., are made from this metal. The difficulties hitherto experienced in the construction of apparatus, in which ammonia and its salts are prepared or utilised, have also been to some extent overcome by its use.

Processes for protecting iron by producing upon its surface an alloy with another metal, have been known for a long time and are still used extensively in the manufacture of tin plates and galvanised sheets. Latterly, however, the methods whereby this is achieved, known as sherardising and calorising have been improved by heating the metal in a mould surrounded by compressed zinc or aluminium dust. Iron, copper, or other metals may be thus treated and there is little doubt but that this treatment will extend the range of their utility, and at the same time lead to further experiments of this kind being undertaken.

Stoneware made from various kinds of clay is still largely manufactured for chemical plant construction, but possesses physical disadvantages, in addition to being a material of variable chemical composition. The same applies to bricks for furnace use made from various refractory materials. The tendency in this case is, however, to use those made from pure constituents, since their properties, as well as those of the binary compounds formed, can be more easily investigated. Much fundamental research has been accomplished recently in this direction, more especially with regard to the physical constants of the pure substances, but a knowledge of what has been done proves convincingly the magnitude of what there is yet to do.

In addition to the metals already mentioned, a large number of alloys of the common metals other than iron, have been and are being investigated, but so far none of these have entered more extended fields of utility.

The great progress made by physicists in the measurement of high temperatures in recent years has placed in the hands of the chemist instruments of invaluable assistance for the regulation of chemical operations on the large scale, and their use has contributed largely to increased efficiency in production.

With this brief notice of the materials now available for industrial chemical operations, due to the advances in the methods of production made during the last two decades effected by a study of the requirements demanded in modern chemical processes, let us now turn to the industries themselves, confining our attention to those, whose origin dates back no further than the conscious memory of most of us here to-night.

When the navigation of the atmosphere by means of airships became a serious problem, the advantages, which would accrue from the use of hydrogen as a lifting medium were so apparent, that the methods of its technical preparation became at once a subject for immediate investigation, with the result, that it is to-day a commercial article of great importance. Formerly its chief use was limited to the working of the platinum metals, and for this purpose the ordinary text-book method sufficed for the preparation of the comparatively small quantities required. These, however, were soon found to be outside the limits of economy, and the following is a brief summary of the processes since utilised, most of which are new.

1. From acids—by the action of metals. In spite of the fact that the cheapest acid and the cheapest metal, namely, iron and sulphuric acid, were used, this process proved expensive and tedious owing to the large quantities required, and has long since been discontinued. A pre-war Zeppelin had a capacity of 25,000 cubic metres, and a little calculation shows that 69 tons of iron and about three times as much chamber sulphuric acid would be required for the production of the necessary hydrogen. Later Zeppelins are stated to require from one and a half times to twice as much.

2. From alkalis—by the action of aluminium or silicon. Both these methods have been found convenient for military use in portable generators. A modification of the second method is known as the "hydrogenite" process, this substance being a mixture of ferro-silicon, sodium hydroxide, and slaked lime, which burns when ignited, producing hydrogen and the silicates of sodium and calcium, 1 kilo yielding about 300 litres hydrogen.

3. From water (*a*) by the action of "hydrone," a lead sodium alloy.

(*b*) By the use of "hydrolith," commercial calcium hydride, prepared by passing hydrogen into molten calcium, 1 kilo yielding about 1 cubic metre.

(*c*) As a bye-product in the electrolysis of solutions of caustic soda and potash, and sodium and potassium chlorides. Large quantities are now obtained from this source at the low cost required for compression and storage.

(*d*) By electrolysis, which unfortunately does not give a pure product unless special precautions be taken.

(*e*) By heating a mixture of barium sulphate and manganous oxide to a white heat and passing steam over the product so obtained.

(*f*) By the action of steam on iron. This method is one of the most important, owing to the fact that the oxide of iron thus produced can be reduced by water gas, and so large quantities of gas can be obtained. The reactions take place at temperatures ranging from 700°—800° C., and the technical difficulties of the process are now stated to have been overcome, so that pure hydrogen containing only traces of nitrogen can be prepared by this means. The method of Bergius makes use of the same reaction in another manner, namely, by the action of water on iron filings at high pressures, up to 300 atmospheres, and at the comparatively low temperatures of 300°—350° C. in the presence of catalysts. The yield is stated to be quantitative, the gas 99·95% pure, at once ready for use, and the cost about three farthings per cubic metre. This process is also extremely interesting from a theoretical point of view, as it is one of the few chemical reactions, where the effect of high pressures has been studied.

(*g*) By the action of steam on coke producing "water gas," which contains approximately equal volumes of hydrogen and carbon monoxide and about 8% nitrogen and carbon dioxide. By extracting the latter with alkalis and cooling the residual gases with liquid air, the nitrogen and carbon monoxide are liquefied and a gas of

97% purity obtained at a cost of 1½d. per cubic metre, and a second liquefaction brings this up to 99·3% and the cost to 2d. The carbon monoxide separated can be used for heating or power purposes to drive the liquid air plant. This, the Linde-Frank-Caro process, and the iron process mentioned above form the two chief methods for the technical preparation of hydrogen, the next in importance being the various electrolytic processes.

4. By the electric decomposition of compressed acetylene. The bye-product obtained in this process is lampblack, which finds a ready market.

Although, at present, the practical utilisation of airships lies in their military value and not in the direction of active competition with other modes of locomotion, yet hydrogen has been of service in many other ways, such as the manufacture of fused silica ware, the preparation of metallic filaments for electric lamps and autogenous welding of metal sheets. The discoveries of Prof. Sabatier, of the University of Toulouse, and his pupils from 1897 onwards, of the preparation of saturated from unsaturated organic compounds by the use of metallic catalysts, especially nickel in a finely divided condition and the specific application of this method by Normann in 1903 to the preparation of solid saturated acids and glycerine from the unsaturated liquid compounds by the addition of hydrogen have founded an industry, which is already extensive owing to the fact, that bye-products formerly of little use can now be converted into stock for the soap and candle industries. It may interest members to learn that a "fat hardening" plant for this purpose, has been at work in this country for a short time whereby whale oil can be rendered of use for the manufacture of soap. The possibility of the manufacture of edible fats by this process assures its further development in the future.

Again, the theoretical study by Prof. Haber and his pupils of the conditions necessary for the union of nitrogen and hydrogen to form ammonia, led to the installation of a plant for this purpose in 1912 at Oppau. Incidentally, the further conversion of the ammonia produced by this or other means into nitric acid, by passing it in admixture with air over electrically heated platinum gauze has assisted to make Germany independent of external help for this valuable munition since the war began. Both these industries are of very recent origin, and there can be little doubt, that both will assume larger dimensions in the near future, the former for the production of a necessary foodstuff, and the latter as a fertiliser of great potentiality. Both emanate from academic chairs, from that atmosphere of "pure" science, which is the nightmare of the self-styled practical man and the life blood of his daily routine.

The chemical investigations of the last half century into the food required by both plants and animals, including man, have proved conclusively the colossal importance of the element nitrogen, which in its elementary form cannot be assimilated, but on the other hand is of vital necessity. The development and utilisation of the Chilian nitrate deposits, the extent and life of which have been variously estimated from time to time, were a direct result of the chemical investigations of Liebig about the middle of the last century. The relation of these deposits to the increasing population and the wheat lands required to provide the necessary food led to the now classic warning of Sir Willliam Crookes in 1898, and his trumpet call to his own profession. The result was, that, within a few short years, the problem of converting atmospheric nitrogen into a form, in which plants could make use of it, was successfully solved. Nitrate production in Chili continues to the approximate extent of two and a half million tons per annum, and the nitrogen of coal is being conserved in some slight degree in the form of ammonium sulphate, about one million tons per annum being recovered. Both these salts are used to the extent of approximately 95% for purposes of agriculture, and their production has not been affected by the commercial atmospheric nitrogen processes, which made their first appearance in 1903.

Briefly, those which have achieved or promise success, may be summarised as follows, according to the method of combination of the nitrogen.

1. *Union with Oxygen* forming nitric oxide, which then unites with another atom of oxygen, yielding the peroxide. This is dissolved in water by passing through granite absorption towers, and yields directly a mixture of nitrous and nitric acids, up to a strength of 35% calculated as HNO_3, which by utilising the waste heat of the furnace gases can be evaporated to 50% HNO_3. Further concentration is carried out, if necessary, by ordinary

methods. The mixture of nitrous and nitric acids first obtained is converted into nitric acid by the peroxide, which is reduced to nitric oxide and again allowed to oxidise by circulation through the system. By neutralisation calcium nitrate was first manufactured, but its property of deliquescence led to its replacement by the basic salt, and this was sold under the name of Norwegian nitrate as a fertiliser. To-day it is found more satisfactory to market concentrated nitric acid. Three types of furnaces have been successfully used to bring about this reaction, the first introduced by Prof. Birkeland and Mr. Eyde being a thick lens-shaped furnace with an arc expanded to a disc, the so-called electric sun, by means of a powerful electro-magnet. Later Dr. Schönherr devised a tube furnace with spiral arc, and Mr. Pauling a narrow furnace with a fan-shaped arc, broadened by separating the electrodes as in a lightning horn arrester. The electrodes require to be water cooled in all cases and their life is short. These arc processes require a large expenditure of electrical energy and can only be profitably worked in places, where it can be obtained extremely cheap. The concentration of nitric oxide in the gases issuing from the furnaces is about 1½% and this amount, as has been demonstrated by Nernst, is strictly regulated by the Van't Hoff equation and is incapable with the temperatures at command of much further economic increase. Sodium nitrite required for dye production has also been manufactured by this process. Normally, about 95%—96% of the nitric oxide is obtained on a commercial scale, the rest being unrecoverable.

2. *Union with Hydrogen.*—This method due to Prof. Haber and his pupils has already been mentioned, since one of its raw materials is hydrogen. The other is nitrogen prepared by liquefaction of the atmosphere, after removal of the carbon dioxide and water and fractional distillation of the liquid air by Linde's methods, oxygen being a bye-product. The reaction succeeds best with the use of metallic catalysts or their carbides, especially uranium and osmium at high pressures (200 atmospheres) and temperatures (500°—700° C.). The thermodynamic equilibrium was carefully worked out under varying conditions, and for the above a conversion varying from 5%—18% was obtained, though it is doubtful if the higher numbers would be got in practice on a large scale. These low amounts necessitated the recirculation of the unconverted gases over the catalyst, and this was accomplished by liquefaction of the ammonia formed, firstly by transference of some of the waste heat to the incoming gases and then cooling in alcohol mixed with carbon dioxide. This process was put into commercial operation just before the commencement of the war and no details have as yet been published.

3. *Union with Metals.*—Boron, silicon, lithium, barium, calcium, magnesium, iron, manganese, titanium and aluminium, possess a marked affinity for nitrogen and many suggestions have been put forward for utilising these substances as a means of nitrogen fixation. The only one, however, which has been tried on a large scale is Serpek's process for the preparation of aluminium nitride, by passing a current of nitrogen over mixtures of alumina and coal, and later by passing ordinary producer gas, containing about 75% nitrogen over a mixture of bauxite and coal at a temperature of about 1,800° C. The advantages of the process are the ease of preparation, the small consumption of electric energy and the facility with which ammonia can be formed by the action of water or alkali solutions yielding alumina, which can be used again in the operation. A trial plant was erected in Alsace in 1905, and just before war broke out a manufactory was established in Savoy. This method is by far the most promising of its class.

4. *Union with Carbides.* — The only method of technical importance other than those mentioned, is one which has a peculiar association with the Rand in that its development was an outcome, almost accidental, of the search for cheaper methods for the commercial production of cyanides. Before the Anglo-Boer War, one method of manufacturing cyanides consisted in passing pure nitrogen at a red heat over barium carbide, which gave a product containing 30% cyanide and 70% cyanamide. This was fused with soda and leached with water giving barium carbonate, which could be used again for preparing the carbide. The solution containing sodium cyanide was converted into ferrocyanide, which was obtained pure and on fusion with sodium yielded the cyanide. The lower prices which prevailed after the war compelled cheaper production, and in place of the barium carbide, the calcium salt was tried

and found to be effective, but in place of soda common salt was used, and the resulting cyanide treated with a mineral acid liberating hydrocyanic acid, which was absorbed in alkali solutions, and then concentrated in vacuum pans, yielding the well known salts of high purity used here. In 1901, however, it was discovered that calcium cyanamide, the chief product obtained from calcium carbide, could be used directly as a nitrogenous manure, and the vast importance of this led the inventors to direct all their energies towards this end, in other words, to aim at securing as large an absorption of nitrogen as possible in the final product with the greatest economy in manufacture, and with the single purpose of preparing a substance most suited to agricultural needs. That this has been achieved is shown by the fact, that, of all the processes for the fixation of atmospheric nitrogen, this is the one now most extensively used, factories having been established in Canada, Norway, Sweden, Belgium, France, Switzerland, Italy, Japan, Germany and Austria. The reasons which have led to this expansion are, firstly, the universality and cheapness of the necessary raw materials, and, secondly, the amount of electrical energy required, which is much smaller than in any other of the processes mentioned, owing to the fact that the heat given out in the formation of the cyanamide can be utilised to complete the reaction. Again, by the action of water ammonia is obtained, and this on oxidation yields nitric acid. Mr. W. S. Landis, of the American Cyanamide Company, in a recent article states that "assuming for the sake of comparison the end product of the cyanamide process is nitric acid, the power consumption required for fixing a unit of nitrogen by this process is only one-fifth to one-sixth that of the arc process." In this country, with relatively abundant supplies of lime and coal, this is the only well known process that is feasible, on account of its much smaller requirements of electric power and the production of a substance, which can at once be utilised for its basic industries of mining and agriculture. I shall close this brief review of one of the most important developments of chemical industry with another quotation from Mr. Landis's paper, which requires no comment: "Recent developments in the nitrogen fixation industry have been on a scale unheard of in the world's history. Installed capacity for nitrogen fixation expressed in short tons nitrogen per year in 1913 and at the beginning of 1916 throughout the world, are shown below:—

	Short tons Nitrogen per year. 1913.	Short tons Nitrogen per year. 1916.
Cyanamide process ...	65,590	209,510
Arc processes ...	18,650	29,400
Synthethic ammonia process	8,000	60,000
Total ...	92,240	298,910

As most of this increase was made in 1915, we note that in practically one year the industry showed an increase of more than 200%. One million horse-power is now consumed in the three groups of processes enumerated above."

At this stage it may be noted, that the means for the production of low temperatures by liquefaction of low boiling point gases, such as the main constituents of the air, has within the period dealt with made such strides, as to render progress possible in other directions, especially those mentioned above, and the rectification of air by fractional distillation has provided an economic method for preparing on the large scale nitrogen of a great degree of purity. The advance which has been made in refrigeration is shown by the fact that ammonia machines give a temperature of −20° C., sulphurous oxide −30° C., carbon dioxide −40° and liquid air −190° C.

In the synthetic organic dye industry highly concentrated sulphuric acid is a prime necessity, as also in the manufacture of nitro-glycerine and nitro-cellulose of various kinds. Formerly this was manufactured by concentrating the comparatively weak chamber acid and its production therefore involved two operations. A theoretical study of the necessary physical conditions for effecting the union of sulphurous oxide and oxygen led to its realisation on the large scale, and set up a formidable rival to the old chamber process, which in consequence has undergone many improvements. The smelter fume problem in America, of which legislation compelled a solution, stimulated the construction of contact plants, and in this connection it is interesting to hear the testimony of a high authority on chemical industry that "for the same weight of platinum the Americans have increased their output threefold." In this country the bulk of the sulphuric acid is manufactured for the explosives industry by this process. For the present, however, there is little doubt that the old chamber process will hold its own, owing to the fact that by far the largest consumption of the acid takes place in the superphosphate industry, and for this purpose chamber acid is used.

Intimately connected with this industry is that of the alkalis. The Leblanc process has now been in use for over a century, and its virile competitor, the ammonia soda process, for half that period. Recently the conversion of hydraulic into electric energy has given rise to the electrolytic alkali industry, which is now firmly established, and from which products more varied and valuable are obtained. The electrolysis of common salt solutions yields chlorine, sodium, sodium hydroxide, hypochlorite and chlorate, according to the cell used. Elementary chlorine has been an article of commerce for some years, and is utilised for the manufacture of bromine and bleaching powder, for detinning waste tinplate scrap, which is now a large industry, and for the manufacture of chlorinated organic compounds, e.g., chloracetic acid in the synthetic indigo process, for making carbon tetrachloride and sulphur chloride, and in general as an oxidising and bleaching agent. Sodium is used chiefly for the manufacture of cyanide and peroxide, and the uses of caustic soda are well known. By allowing the products of the electrolysis to react upon each other at a low temperature, hypochlorite is formed, and at a higher temperature, chlorate. The former compound prepared by this method has been used very largely for many years for water sterilisation and in hospitals, and small plants for obtaining it from sea water have now been installed on the large ocean liners for disinfectant use. Chlorates are now made exclusively by electrolysis. Hydrogen is likewise obtained in large quantities as a bye-product in these processes, and at first was allowed to escape, but is now utlised as already mentioned. Electrolytic decomposition of fused salt has also been undertaken with success, and as conducted on the large scale shows a high energy efficiency.

It would be extremely rash to hazard any opinion on the future success of these rival industries, since there are so many conflicting factors which must be taken into account. Primarily, the industries utilising electrical energy are dependent on its low cost, which at the moment can be obtained most efficiently from water power, and this is only possible at certain isolated centres, which are in most cases situated at some distance from the most profitable selling markets. Again, the question of power in chemical processes, though of extreme importance, is by no means the only factor to be considered, so much so, that it is by no means rare to find that a process, which promises well when carried out in the laboratory, is almost impossible to realise commercially.

On the other hand, the utilisation of cheap electric power has created a revolution in the art of preparing certain metals, namely, sodium, aluminium, magnesium, and calcium, as well as in the refining of copper, lead and gold. The electro-thermal furnace preparation of steel is capable of wide expansion, but it is very doubtful if iron will be reduced from the ore by this method except at the cheapest centres of electric power production, such as are found in Scandinavia. Of very recent date is the introduction of soft electrolytic iron on the market, which owing to its valuable properties is used in the manufacture of electromagnets in motors, thereby increasing their efficiency, as it becomes magnetised and demagnetised much more readily than the iron hitherto used for this purpose.

Another group of industries directly due to the harnessing of the Niagara Falls is connected with the re-discovery of silicon carbide by E. G. Acheson in the last decade of last century, and now comprises the manufacture of this substance, known commercially as carborundum, artificial soft graphite, and hard graphite electrodes for use in electric furnaces and electrolytic cells. Carborundum is prepared by decomposing in the electric furnace a mixture of sand and coke containing a small percentage of sawdust and common salt. Owing to its great hardness, being next to the diamond in this property, it is chiefly used as an abrasive. Electrodes are made similarly by heating amorphous carbon articles moulded to the shape desired. Soft graphite is prepared by the decomposition of carborundum at a very high temperature, when the carbon splits off in this form. The nature of this reaction is interesting, since only a small quantity of carbide is necessary to bring about the transformation of a large quantity of carbonaceous material. A further discovery of Acheson's may also be mentioned, namely, the production of colloidal graphite by a treatment of the soft furnace variety with a solution of tannin, a method which has largely increased its powers and use as a lubricant, thus assisting towards a solution of the problem of power control.

The demand for oxidizers which contain a large percentage of available oxygen, has led to the industry of the so-called per-salts, and at the same time to the marketing of stabilized hydrogen peroxide of great purity. Persulphates, perchlorates and perborates are now prepared commercially, the latter being marketed for use in laundries under the name of persil or perborin. On the other hand, the powerful reducing agent sodium hyposulphite is now an important commercial article, being marketed as the solid anhydrous sodium salt for use in dyeing processes.

The rarer metals have contributed largely to our welfare, more particularly with respect to increasing the efficiency of coal-gas and electric current as illuminants. In the former case the manufacture of the well known gas mantles is carried out by dipping the cellulose fabric in a solution containing a large percentage of thorium nitrate with small amounts of cerium or other rare earth nitrates. The consumption of these mantles in Europe and America amounted, in 1912, to over 220,000,000. Although introduced only a short time ago the replacement of carbon filaments in electric lamps by the rare metals osmium, tantalum, and latterly tungsten, with an economy of 60% of current, are well known; and nitrogen and even argon are replacing the vacuum. An iron cerium alloy, containing 65% cerium, known as Auermetal, after its discoverer, is the modern substitute of the ancient flintstone.

Lastly, a huge industry has been recently created by the use of the oxyhydrogen flame in fusing alumina, both pure and coloured, with iron, titanium and chromium oxides for the production of artificial rubies, sapphires, etc., identical in all their properties with the natural gems, and now largely used both for jewellery and scientific instruments.

From the above survey of the field of applied inorganic chemistry the intimate connection between progress and electrochemical energy has been frequently mentioned. In the region of the organic chemical industries this has played a far less conspicuous part in spite of the endeavours made to take advantage of it; on the other hand, there is no field in the whole realm of science which demonstrates so clearly and conclusively the tremendous potentiality and power of scientific research. The synthetic production of indigo made economically possibly by the development of the contact process for sulphuric acid is the most brilliant result in this field, but this is by no means the only triumph. The story of the utilisation of coal tar distillation products has been repeated so often that even the man in the street now attempts to arrogate to himself the knowledge expressed in the term coal tar dyes, an industry born in England and reared to an undreamed of perfection in Germany, so much so that at the outbreak of the present war the textile industries of England, worth £200,000,000 per annum, found themselves in a critical condition when imported dyestuffs, valued at £2,000,000, were cut off, a state of affairs which to some extent has since been happily remedied. The mother substances, from which these dyes are prepared, are benzene, naphthalene and anthracene, obtained respectively from the light, medium, and heavy oils of tar. A mere list of the colours which have been derived therefrom would cover many pages, but would be out of place here. It will be sufficient to indicate the events of main importance.

The synthesis of alizarin in 1868, by Graebe and Liebermann, and its appearance on the market a little later, resulted in the gradual and finally complete displacement of the natural product, and at the same time, owing chiefly to the large profits secured thereby, stimulated a keen and intense interest in the subject, the consequences of which were soon manifested by further discoveries, such as the eosins, chrysoidin, methylene blue, malachite green, auramine, naphthol black, congo red, rhodamine, etc., etc. At this period Baeyer undertook his researches into the indigo formula, which ended in a successful laboratory synthesis in the early eighties, and the dream, that the indigo plantations of India should share the fate of the madder fields of France, was the next goal to be achieved. Sixteen years' work and a million of money brought success in 1896.

Since then a number of valuable substituted indigos have been discovered, one of which is well known to history as Tyrian purple. Also from anthracene the vat dyes of the indanthrene series of colours have been discovered since 1903, and form some of the most stable dyes known, possessing a much greater resistance to light, washing, etc., than any of the dyes hitherto obtained.

Simultaneously in other groups, *e.g.*, the azo and phthalein groups, research has evolved new substances of importance in this connection, and at the same time there has been a gradual progress in the perfection of methods of factory control, and especially in apparatus.

A large amount of research has also been undertaken to determine the relation, if any, between the colour and the constitution of these compounds. The auxochrome-chromophore theory of Witt, and the quinonoid theory of Armstrong are both capable of rendering much assistance, but, on the other hand, do not meet all cases; both theories, however, claim earnest supporters. Professor Baly has worked largely in this field by studying the absorption spectra of a large number of compounds, and has deduced many interesting facts. The problem is, however, by no means solved, and it is as yet therefore impossible to predict the colour of a compound from its previously ascertained constitution.

Three vigorous and closely allied industries have arisen from the dye industry and have now attained such proportions as to claim positions of their own, namely, those connected with the preparation of (a) artificial medicines, (b) artificial perfumery, (c) photographic chemicals.

The first of these industries had its birth in a search for quinine substitutes, and the first result was the discovery of antipyrin by Knorr in 1883 by the condensation of phenyl hydrazine and aceto-acetic-ethyl-ester followed by methylation. The antipyretic properties of aniline and acetanilide were also discovered about this time, but the former was found to be toxic, whereas the introduction of the acetyl group decreased this to such an extent that it was used in medicine under the name antifebrin. A very large number of antipyretics and analgesics have since been discovered, the most important of these being pyramidon, a derivative of antipyrin and three times as powerful, and phenacetin (p-ethoxyacetanilide). Amongst general anæsthetics, narcotics, and hypnotics, we have chloroform, discovered in 1831, ether, ethyl chloride, choral and bromal hydrates, chloretone (acetone chloroform), mercaptan derivatives such as trional, tetronal and sulphonal, and derivatives of malonyl urea, such as proponal, veronal and medinal, its soluble sodium salt. Local anæsthetics of extreme value and widely extended use have been prepared synthetically, such as the α and β eucaines, stovaine, holocaine, novocaine, etc. Phenol and its derivatives are largely utilised on account of their antiseptic properties, and the anti-rheumatic properties of salicylic acid and its acetyl derivative, aspirin, are well known. Solvents for uric acid, *e.g.*, piperazine and atophan, purgatives and diuretics are also prepared in large quantities. The valuable styptic adrenalin isolated from the suprarenal glands, was synthesized by Stolz in 1904, and is now manufactured for therapeutic use. The researches of Ehrlich and others on organic compounds containing arsenic and antimony and their therapeutic effects, led to the introduction of atoxyl for the treatment of syphilis and sleeping sickness, and the results obtained showed that these organic derivatives possessed a greater potency than the inorganic compounds of these elements, which had hitherto been used chiefly as tonics. At the same time an attempt was made to connect chemical constitution with therapeutic action, in order to guide future research, an effort which proved of much service. Of the many compounds isolated, the most widely known is dihydroxy diamino-arseno-benzene hydrochloride, sold commercially as "606" or salvarsan, which has now become a specific in the treatment of syphilis. The most important feature of this work is, however, the foundation of the science of chemotherapy.

The industry in synthetic perfumes dates from 1876, and during the last two decades has reached large dimensions, the annual output in Germany alone having a value from two to two and a half million pounds. Ionone is now the basis of synthetic violet perfumes, and the main constituent of oil of bergamot is linalyl acetate. The odours of musk, carnation, heliotrope, rose, hyacinth, jasmine, etc., etc., can be faithfully reproduced by compounds prepared synthetically in the laboratory, and the majority of flavouring essences used in confectionery, etc., are prepared in like manner.

In photographic goods, such as lenses, plates, chemicals and films, it is difficult to get statistics of the dimensions of the industry, but the chief countries concerned are Great Britain, the United States, France, Germany and Austria. In 1912 Germany alone exported these to a value of over a million and a half pounds. Most of the developers used in photography, such as pyrogallic acid, hydroquinone, adurol, amidophenol and its derivatives, namely, rodinal, metol, ortol, and amidol, are prepared from coal tar by those same methods which have been developed to such perfection in preparing dyestuffs.

Another industry which has emanated from the organic laboratory and promises to attain large dimensions, has been created by Professor Baekeland, late of the University of Ghent, inventor of the well known velox paper. It consists of the manufacture of bakelite, a trade name for the various resinous condensation products obtained from phenol and formaldehyde and their homologues. The uses of this material are so extremely varied, that in 1913 the statement was made, that it was being worked up in twenty- four different industries, about 1,000 workmen being employed on the product in the button industry alone.

Lastly, there are the cellulose industries, which may be grouped together, as this substance is the raw material for most of them. In the first place pure cellulose is now produced very largely from wood pulp by chemical means, and this forms an important source of raw material for the manufacture of paper. In 1884-8 Chardonnet was the first to obtain artificial silk by nitrating cellulose in the ordinary way, and after getting rid of excess acid, dissolving the product in a mixture of alcohol and ether, which was then allowed to stand for some time and finally pressed through minute tubes into acidulated water. Threads were thus formed, which were first dried quickly and afterwards denitrated in a bath of alkaline sulphide, washed and dried. Since then other methods have been discovered, and of these the cuprammonium method used in Germany and the thio-carbonate method of Cross and Bevan have been commercially successful, particularly the latter, which yields viscose silk, and promises to outstrip all the rest. The acetylation of cellulose carried out by using acetic acid or anhydride and various dehydrating agents, has given rise to valuable products. When the variety, which is soluble in alcohol, is mixed with camphor in the presence of a liquid medium, and the solvents evaporated off cellit or cellon is obtained, which is a non-inflammable celluloid, and can be used for a large variety of purposes, from making patent leather or bioscope films to coating the fabrics used in machines used for aerial navigation.

It is also worthy of note that in 1913, Professor Emil Fischer elucidated the structure of the tannin molecule, and has thus opened up new avenues of industrial research for the substitution of artificial products in place of the natural tanning materials now in use. The importance of this discovery to South Africa I have dealt with elsewhere.

In concluding this brief survey of some of the benefits chemical science has wrought for the welfare of mankind during the years which have elapsed since the foundation of this society, I venture to say without hesitation or even a single thought, such as might be born of a fear of contradiction, that the mere recital of the stupendous progress outlined above gives cause for reflection on the future empire within the chemist's grasp. Even a casual perusal of the list of the elements at present known will demonstrate that the large majority of them are not yet harnessed in the chariot of industrial progress. Indeed, many would doubtless regard them with the same ignorant curiosity, with which for the most part they view the objects displayed in a well ordered museum. But the chemist knows full well, that the history of his science is crammed with instances where research, nobly undertaken to advance its boundaries and with no thought of the patent office, has ended in creating new avenues of productive industry. Aluminium, one of the most abundant elements on the face of the earth, was but yesterday a wonder specimen of the chemist's museum, to-day it stares at you from every shop window. The physicists, Joule and Mayer, in the middle of last century experimentally demonstrated the law of the conservation of energy, the engineer inspanned the water falls, and the chemist at once dragged the beautiful metal from its mummified case for man's daily use. The Indian planters grew the king of dyestuffs in their sunlit fields and smoked their cheroots complacently, whilst Baeyer delved deep into its molecular constitution and finally wrung it out of coal tar. The wattle planters of Natal are wrapped in peaceful slumber on the verdant slopes of Maritzburg, whilst Fischer synthesises a purer product in Berlin. The quest for cyanide resulted in a world industry of a magnitude exceeding the wildest imagination of the chemists who engaged in it.

But even more vital to a country's progress are the stores of energy she holds within her womb, without which matter is as nought, and in this respect South Africa is indeed in happy case. Her small stores of coal will serve to guard her infancy until the day shall dawn, when her physicists will yoke the sun and transform its energy directly but efficiently into the plastic form of the electric current, or better still when her chemists shall convert it without an intermediary into chemical energy to be utilised for the subtle synthetic operations similar to those we now observe with wonderment in the plant world.

To-day we stand on the threshold of a newly born country with the raw materials for industries, proved and established in other and older countries, here in plenty. The smallest legacy we can bequeath to future generations is to make some attempt to utilise them. This will constitute the foundation for the future progress of the race, the corner stones of the nation's well being. The distant roar of the guns still sounds in our ears, but the days of peace are now, we hope, not far removed. As members of a progressive Society dedicated to science and scientific truth, it is our bounden duty to be prepared and to arm ourselves for the advance.

Dr. James Moir *(Past-President)*: I wish to ask the meeting to accord a very hearty vote of thanks to Prof. Wilkinson for his Address. I confess that one is taken rather at a disadvantage by being expected to discuss an address on such a wide subject, but I will say that I do not know that I have ever heard or read such a lucid exposition of the subject of chemical industry, and that at times, the Professor was positively eloquent. Now it is true that the subject is a great one and deserves eloquence, but there are very few people who are absorbed in chemical or scientific affairs, who have the gift of presenting the subject in an attractive form like this.

With regard to the subject matter, I do not think there is anything special to speak about, except to ask a question or two. We have first the processes for utilising atmospheric nitrogen. I should like to ascertain Prof. Wilkinson's personal view as to whether the first of these processes can be applied to South Africa at all? We have always understood from the newspapers that the other two processes (viz., the nitrogen arc and the Haber ammonia processes) were the ones on which the Germans were dependent for their supplies of explosives, which they have mostly got from Norway and Sweden. I am surprised to learn that the cyanamide process is so good. With regard to synthetic ammonia, it is quite true that Prof. Haber and his pupils have been the people to make it a commercial success, but I might point out that the actual scientific basis of it was discovered in England probably as far back as 1860, but there was no encouragement to scientific people in England to attempt to make it a commercial process.

Then another point is with regard to the organic side of chemical industry. The question is whether any investigation has ever been done of such coal-tar as can be got from South African coal: whether it is possible to get benzene, naphthalene, etc., from it. We have everything else in South Africa for making the whole of the synthetic things we require—every other substance—but this point does not seem to have been investigated by anyone. It is possible that owing to bad condensation there is no benzene in local tar, and I wonder whether it is possible to break down by heat or otherwise the more complicated compounds which are known to exist in the coal tar as supplied so as to produce benzene, etc. Then as regards the drug "606," which is said to have obtained its name because Ehrlich made no less than 605 previous attempts to get a drug with the required properties; I think that is a wonderful example of foreign genius, particularly German genius. It is not genius at all, but merely plodding, or taking pains. I am quite sure if an Englishman had been set to tackle the problem, he would have had about 20 tries, and would then have solved the problem, or given it up as not worth the time!

Mr. H. A. White *(Vice-President)*: I should just like to briefly second the vote of thanks and, in doing so, to call attention to one little statement, and that is, to turn the production of indigo into a commercial success, it took 16 years at a cost of 1,000,000 pounds; and, unless the Government of this country is going to spend money and plenty of time on scientific research, they must take it for granted that no valuable results are going to be achieved here.

The President: I thank you for the vote you have just accorded me, and also Dr. Moir for the gracious manner of its proposal. In reply to the questions, which he has put, I desire to state that the arc processes with their great consumption of electric energy would not, in my opinion, be feasible in

South Africa nor, indeed, at any place except those, which can produce electric power at a very cheap rate. So far as I know, arc processes are at work only in Norway and Germany. A short time ago there was much discussion in America on the process of nitrogen fixation to be installed there, and the final decision was that the cyanamide process would be the most suitable. A Pauling plant was established independently, but it has had a precarious existence, whereas its cyanamide competitor is in a flourishing condition.

With regard to the conversion of ammonia into nitric acid, a paper* was recently published on the Ostwald process, from which I gleaned such details that I ventured to state that it was now a commercial success, a conclusion, which, I think, is also supported on general grounds. With regard to the question of the priority of its discovery I cannot speak.

I should like to endorse what Dr. Moir has said regarding the encouragement hitherto given in England to research. When Prof. Haber began his research on the union of nitrogen with hydrogen, he did not undertake the work from a commercial point of view, but soon it was obvious, that if he could solve the problem, there was promise of a great commercial success. This has been achieved by the Badische aniline and soda factory and the figures given are eloquent of their opinion of it.

The question regarding coal tar of South African origin is one I am unable to answer, because I do not know of any investigations, private or otherwise, on this subject.

With regard to "606" and the statement that 605 compounds had been previously made, I can find no authority to prove its truth, but I can quite believe it to be true knowing the meticulous assiduity of the German genius.

I desire once more to offer my sincere thanks for your vote.

THE VALUATION OF MINES.

By Prof. R. A. Lehfeldt, D.Sc.

(*Printed in Journal, September, 1916.*)

DISCUSSION.

Prof. Lehfeldt: This paper has already appeared in your *Journal*, so I do not imagine that you wish me to go over it again. The object of the paper is to work out the value of a mine under certain defined conditions. Of course, it may be objected that not enough is known about mines to make it worth while; but in the books on mining economics will be found arithmetical discussions of cases, which are supposed to represent the facts in these particular mines, and I thought it might be useful to introduce into such statements the generality, which such methods give. Arithmetical examples are always apt to be misleading, because there is no guarantee as to what would happen to the results if the data were modified.

Mr. H. A. White *(Vice-President):* It cannot be doubted that the author has performed most useful service by arranging in mathematical symbols the principal factors determining the most profitable scale of operations for a mine whose ore contents are approximately known.

The assumptions appear to be reasonable, though exception might be taken to the time starting point chosen, as in itself the time of starting the mill is partly dependent upon the scale of operations: it is difficult however to suggest a more secure base.

The expression derived from T optimum) is printed with a positive sign before $\frac{cX}{T^2}$, which is apparently incorrect, though the simplified form (3) is correctly given.

The graphs illustrate the fact that the rate of interest is not nearly as important as value of the ore in determining most advantageous life, which for most probable cases must lie between 9 and 14 years. In fact, one might say that 11 years is the most suitable life for a gold mill on the Rand and yet avoid much greater error than the interplay of inaccurately known factors might cause.

In order, however, to form some idea of capital requirements for a new mine it would be useful to have a simple expression for a probable most advantageous life, and the author's quotation (3) does not quite meet the needs of the case. As, however, the Professor has frankly ignored certain factors, and has to make certain debatable assumptions in order to get so far as he has, it will perhaps be interesting to use his results and methods in the form of a still less accurate and in fact merely approximate expression. In order to effect this purpose one has merely to note that the complications involved are due to T appearing as an exponent, and this again is due to the interest factor.

---

* *Metallurgical and Chemical Engineering*, April 15, 1916.

If we ignore interest entirely, encouraged by its slight effect upon T (optimum), and by the fact that it works both ways owing to its effect upon the "accrued" capital, we get a very much simpler result, as follows:—

Instead of present value at starting of mill we determine total gross profit (P) available, neglecting interest.

Using the other letters in the same sense as in the original paper we have:—

$$P=(p-q)X-C$$

expanding similarly and substituting $\frac{X}{T}$ for x

$$P=(p-\frac{Q}{x}-r)X-C_0-cx$$

$$=(p-\frac{QT}{X}-r)X-C_0-\frac{cX}{T}$$

Differentiating for a maximum

$$\frac{cX}{T^2}-Q=O$$

$$\text{and } T=\sqrt{\frac{cX}{Q}}$$

If we put c (the capital required per ton milled per year) in addition to a fixed sum for the mine, at £1 5s.; Q (the fixed overhead cost per annum) at £150,000 and X (the total tons of ore in the mine) at 20 millions, in accordance with the author's estimates we get:—

$T=\sqrt{200}$, or about 14 years life in this case, and in all cases the value per ton of ore or that part of the cost not affected by working scale have no influence on the result, which is, of course, as it should be if interest is neglected, and in addition renders calculation more secure by eliminating factors which cannot certainly be known till the end of the mine's life.

NOTES ON RARE MINERALS IN MADAGASCAR.

By T. P. Waites *(Member)*

(Printed in Journal, March, 1916.)

DISCUSSION.

The President: Since our last meeting I have had the opportunity of testing four of these minerals, monazite, autunite, ampangabeite and bastnaesite, with regard to their action on a photographic plate. The plates used were Ilford Special Rapid, and the time of exposure given was three to four weeks. In the case of the first three minerals the results were highly successful, and I will now show you the actual results on the screen.

THE MANGANESE SILVER PROBLEM.

By Walter Neal *(Corresponding Member of Council).*

(Printed in Journal, September, 1916.)

DISCUSSION.

Mr. H. A. White *(Vice-President):* The highly interesting problem brought before us by Mr. Neal may be attacked in two directions. The author's method may be described as empirical, and involves the application of all known methods with suitable variations and the comparison of results obtained.

The other method is only partly exploited, though it appears to me to offer the only scientific plan of action and must finally yield a successful result if such is commercially possible. Briefly, this second method is to ascertain the cause of the trouble and its mode of action.

I propose to trace as far as possible from the facts given what is this cause of low extractions on silver ore in the presence of manganese, and to suggest methods of obtaining further data required. Confining discussion to the most refractory ore mentioned, that of El Favor, it is at once obvious that some oxide of manganese is responsible, and then only when total silver is not in form of sulphide. To confirm this, pure silver sulphide, up to say 20 oz. per ton might be added to a sample of the ore, and the extractions by cyanide from the mixture and from the ore alone could be compared.

The following experiments indicate that manganese dioxide has no significant action on cyanide solutions carrying silver, either in decomposing cyanide or precipitating silver. (A) 2,000 cc. of a cyanide solution to which 200 cc. of N/10 $KMnO_4$ had been added showed 0·333% KCN and an abundant precipitate of hydrated manganese dioxide. This mixture was subjected to a stream of air (freed from CO_2) at the rate of 1 litre per minute for 18 hours. The total cyanide strength remained at exactly the same figure (0·333% KCN) and the final alkalinity was 0·0176% NaHO. The filtered solution was quite clear and colourless

(B) Some precipitated hydrated dioxide of manganese was prepared by mixing hot solutions of sodium thiosulphate and permanganate of potash and thoroughly washing and air-drying. A silver cyanide solution carrying 12·5 oz. to the ton and 0·50% KCN was prepared, and two lots of 5 A.T. therefrom each shaken up with 1 gm. of the MnO_2 precipitate.

(1) Shaken together for 5 minutes, filtered and washed, the precipitate showed 3·0 dwt. silver per ton of solution.

(2) Repeatedly shaken during 3 days' contact, and the precipitate then washed with especial care. The precipitate showed 0·4 dwt. of silver per ton of solution.

It is obvious that though washing is difficult no great amount of silver is precipitated from cyanide solution by manganese dioxide. This suggests that it is not the mere presence of manganese dioxide in the El Favor ore which is objectionable but that some combination of the silver and manganese is present. To confirm this, an examination of the various concentrates and tailings obtained, and in especial of the flotation concentrate (which separates refractory silver in the tailing) might be made with the idea of ascertaining if the refractory silver is correlated with the manganese dioxide—the Deister concentrate results given suggest that such is the case.

An examination of all the results given suggests that 50% of the silver is in close combination with manganese, 40% exists as silver chloride and the remainder as sulphide and sulpharsenide.

Treatment of the finely crushed ore with (1) saturated salt solution, (2) 5% hypo and (3) 10% ammonia would show how much of the silver exists as chloride as the reagents have little effect on other forms of silver likely to be present. It is also important to ascertain how the manganese occurs, and an examination of the facts given should be supplemented by special analysis for MnO_2 by means of oxalic acid and H_2SO_4, which could readily be done.

The facts given with reference to the action of ferrous sulphate and sulphuric acid would indicate that only a small part of the 3·49% of manganese exists as the dioxide. The reaction

$$MnO_2 + 2(FeSO_4 + 7H_2O) + 2H_2SO_4 = MnSO_4 + Fe_2(SO_4)_3 + 16H_2O$$

requires 10·1 lb. of ferrous sulphate to 1 of manganese, and as 1% of $FeSO_4$ was about enough at a dilution of 4 solution to 1 of ore, it follows that only about 1/9 of the manganese present is in dioxide form: otherwise at the 4/1 ratio the solution strength would have to be about 9% green vitriol and 3% sulphuric acid.

The following further experiments were carried out in order to test the theory that the detrimental manganese-silver compound is silver manganite ($Ag_2O,(x)MnO_2$) which is probably precipitated from ordinary neutral silver salts by manganese dioxide. (See Martin & Lancaster's Chemistry, Vol. VIII., p. 289, Griffin, 1915).

The black oxide of manganese used contained 0·3 oz. of silver per ton and a little lime was present, as usual in the commercial product.

(C) 10 gm. MnO_2, 0·1 gm. $AgNO_3$, and 200 cc. saturated salt solution were well agitated and then filtered. Residue well washed first with saturated salt solution then water, yielded only 0·9 oz. of silver per ton of MnO_2 or 0·5% extraction from the solution, showing that silver in this form (double chloride) as in cyanide solution is not much affected.

(D) 10 gm. MnO_2 were well shaken for 5 minutes with 200 cc. of solution of silver nitrate, 47 oz. silver per ton, and filtered. The well-washed residue assayed 116 oz. per ton of MnO_2, or 12% extraction from the solution.

(E) To confirm this last result and to provide an artificial ore for further trials: 100 gm. of MnO_2 were agitated for 15 minutes with 500 cc. of silver nitrate solution assaying 315 oz. silver per ton and then filtered. Filtrate was neutral to phenolphthalein and showed no trace of manganese, it now assayed only 212 oz. per ton, giving a calculated value to the MnO_2 of 514 oz. silver per ton. The residue was washed six times with distilled water and then air-dried: it then assayed 353 oz. per ton. The difference, 514-353 or 161 oz. must represent surface concentration of silver nitrate displaced by the repeated dilution. See "Surface Tension and Surface Energy, by Willows and Hatschek, p. 46, Churchill, 1915). This washed residue thus showed an extraction of 20% from the solution.

(F) A screen analysis of this artificial ore showed

52·5% + 200 (0·003 in.) value 318 oz. Ag. per ton.

47·5% − 200, value 391 oz. Ag. per ton.

If this precipitation of silver were a mere mechanical surface effect the coarser portion should not assay more than half as much as the fine and the slight difference shown indicates that it is a real chemical effect we are dealing with. Though not really of importance to this discussion, it is thus more probable that we are not dealing with an adsorption but with the formation of silver manganite, and that this is also the case in the El Favor ore. Psilomelane, which is given as prominent in this El Favor ore is an example of the manganite to be considered. Supposing silver manganite to be similar in construction to the known potassium manganite (Roscoe and Schorlemmer, Vol. II., part II., p. 14) the action of SO_2 would be as below:—
$Ag_2O, \quad 5MnO_2 + 11SO_2 = Ag_2SO_3 + 5MnS_2O_6$
The silver sulphite formed though insoluble in water and H_2SO_3 is readily soluble in saturated salt solution, cyanide, thiosulphate, or ammonia as simple experiment will readily prove and the 90% extractions are easily explained.

It will be observed that the principal action of sulphur dioxide upon MnO_2 is to form dithionate and not sulphate as the author has assumed (p. 15). The formation of sulphate takes place as a side reaction to a small extent only, and in consequence the consumption of sulphur will be nearly double Mr. Neal's estimate, and would amount to 80 lb. per ton of ore if all the manganese were in the form of dioxide while regeneration by electrolysis would probably save no more than half the amount used in any case.

It might be worth while to try experiments on this ore with weak ammonia solution, both with and without the sulphur dioxide treatment as if successful the expense would be less than cyanide. Of course in practise the ammonia would be imported as sulphate or chloride and turned into gas on the mine in very simple apparatus, by means of lime. The excess of SO_2 could be washed out if not blown out with air for re-use. I find that two parts of 0·890 ammonia to 100 of water will dissolve in excess of 12 oz. of silver per ton as chloride, and that this silver is readily precipitated on zinc shaving.

The following further experiments were made on the artificial ore referred to above in order to obtain results to be compared with those reported on El Favor ore.

(F) 5 gm. treated with excess of Na_2SO_3 and H_2SO_4 for 18 hours showed only few black specks left. The residue was washed with 1,000 cc. of 0·5% KCN and then assayed 0·6 oz. of silver per ton of MnO_2—an extraction of over 99%. This duplicated the favourable results quoted and the next experiments illustrate the helplessness of the usual methods.

(G) 10 gm. agitated for one day with 1 litre of 0·5% KCN, decanted, residue again agitated for 3 days with second litre of 0·5% KCN, filtered and washed with third litre of 0·5% KCN, then washed with 3 litres of water. Final residue assayed 83 oz. of silver per ton of MnO_2.

(H) 10 gm. agitated with 1 litre of 0·5% KCN and filtered, residue washed with 200 cc. of 10% ammonia then with 1 litre of saturated salt solution. Final residue assayed 86 oz. of silver per ton of MnO_2.

(I) 10 gm. agitated with 1 litre of 10% ammonia, filtered and washed. Residue assayed 73 oz. of silver per ton of MnO_4.

As this artificial ore had a value of 353 oz. per ton, extractions of 75% to 79% are shown in above results; but the refractory residue though so high in value appears not to yield any further value to ordinary treatment. It is therefore submitted that the results thus obtained, taken in conjunction with those quoted in the original paper, indicate not only the source and mode of action of the trouble at El Favor but also suggest the mode of formation of the ore.

As for the overcoming of the difficulty it is rendered probable that no method which does not involve the destruction of MnO_2 can yield a very high extraction. Research must therefore be made in the direction of performing this destruction in the cheapest manner possible, and I would suggest as the most probable method the utilisation of the fact that carbon monoxide at very low temperatures, even below red heat, has a very powerful action upon manganese dioxide.

THE CONGLOMERATES OF THE WITWATERSRAND.

By E. T. Mellor, D.Sc. (Lond.), M.Inst.M.M.

(*Printed in Journal, February, 1916.*)

REPLY TO DISCUSSION.

Dr. E. T. Mellor: Mr. E. Weston, in his discussion, brings out several very interesting points in connection with the banket. The pebble containing gold exhibited by him is the best example I have yet seen of such an occurrence. In most cases which have come under my notice there has always been an element of doubt as to whether the gold contained in the pebble had not been introduced after the inclusion of the latter on the banket, but in this example it has every appearance of having formed part of the original pebble.

With regard to the two kinds of footwall found below the Main Reef Leader in the East Rand, I think Mr. Weston will find that I had already dealt with this point in my previous paper on the Upper Witwatersrand System. It is customary to speak of the footwall throughout the whole Far East Rand as "slate." The reef is, however, very frequently underlain over considerable areas by what is more correctly ascribed as "quartzite."

The vertical thickness of beds removed by denudation in the Far East Rand is a very variable quantity. On the northern margin of the basin it must embrace not only the rocks of the Karroo, Transvaal, and Ventersdorp Systems, but a large part of the Witwatersrand System as well, including the whole of its Upper Division.

The absence of pebbles of recognisable Rand banket in the Black Reef conglomerates does not appear remarkable when we consider that it would be exceedingly difficult to find along the present outcrops of the conglomerates of the Witwatersrand System, any fragment likely to form such pebbles. The individual pebbles separate so readily from each other and from the matrix on exposure at the surface, that a detached fragment of actual banket is very rarely met with.

Mr. Bleloch's view that the Nigel and Van Ryn Reefs are not the same has been dealt with in my paper on the East Rand.[1]

Dr. Young contends that had the deposition of the Main Reef Leader been due to flood action, the direction of the currents would be indicated by imbrication of the pebbles. Would this necessarily be the case? After paying considerable attention to the matter, I am much inclined to doubt whether some of the ideal and theoretical conceptions with regard to the shapes of pebbles and their arrangement are as universally true as they are generally supposed to be. One can see why there is a tendency for pebbles to assume an imbricated arrangement in the bed of a river where they are subjected to the action of a definite current for a considerable time, but it is not so easy to see how a mass of material such as that included in the Main Reef Leader of the East Rand, much of which has the appearance of having been rapidly deposited and not subsequently disturbed or rearranged, should show any marked degree of imbrication. By far the greater number of pebbles in this bed, as far as I am acquainted with it, are of such a form that it would not be easy, even by hand, to give them an imbricated arrangement. Over large areas, in the Far East Rand particularly, the arrangement of pebbles conveys very strongly the impression that they came to rest very suddenly and were rapidly covered by the material immediately above, and this is indeed one of the reasons which led me to ascribe their deposition to such an agency as a flood current. As evidence of the mode of deposition of the Main Reef Leader in the Far East Rand, I think much more definite evidence is to be obtained from a study of the deposit *as a whole* than from the arrangement or want of arrangement of its individual pebbles. When we consider such definite and well established features of this sheet of conglomerate as its wide extent, not only from east to west but also from north to south, the narrow limits between which it varies in thickness, the grading of the pebbles both as to average and to maximum dimensions as we proceed from north to south, its gradual diminution in thickness from its central portions towards its periphery, its elongation in a northerly and southerly direction, its thinning out and breaking up into fringes of elongated lenticular patches on its southern borders, and the orientation of these patches in a remarkably constant direction, when, too, we remember the character of the sediments whose deposition preceded that of the conglomerate bed, it is very difficult to explain these features as the result of truly coastal conditions, whereas on the supposition that the pebble-bed was laid down by a broad current flowing in a definite direction they appear to be easily explicable, and to be as a whole thoroughly consistent. As was emphasized in my paper, many of these features are most clearly brought out in the Far East Rand, where, for the most part, we have to deal with a single conglomerate bed, possessing a strongly marked individual character, and where our observations are not limited to a long and narrow strip in an east and west line and within, say, about 4,000 ft. of the outcrop, as on the Central Rand, but may be extended in other directions for many miles.

---

[1] *Trans. Geol. Soc. of S.A.*, Vol. xviii. 1915, p. 35.

Objections against a fluviatile origin for the pebbles have frequently been based, as in the present instance by Professor Young, and earlier by Becker, on the rounded form which is said to characterise river pebbles, and on the frequency with which "bun-shaped" pebbles occur in the Rand conglomerates. Theoretically, this appears an excellent point, and it is one to which due regard was given in the earlier stages of my study of the conglomerates. As a result of much attention to this question, however, I am inclined to ask, are river pebbles really so universally rounded in shape as they are thought to be and are "bun-shaped" individuals so rare among them and so characteristic of shore deposits as has been stated? Personally I very much doubt whether either of these questions can be answered in the affirmative, and in this connection it is very interesting to consider the pebbles turned out by tube-mills. If the rounded forms supposed to be general among river pebbles are to be attributed to a rolling motion, surely a prolonged sojourn in a tube-mill should be calculated to produce a still more rounded pebble, yet among the pebbles produced in such mills from the fragments of rock fed into them, by far the largest proportion have by no means a circular section in any direction, while a great number are just as much "bun-shaped" as the great majority of those found in the banket. Recently, in company with two other observers, I made a careful search among a large number of pebbles discharged from tube-mills, and was unable to find a single specimen which possessed a really circular section in any direction, while the great majority gave a section either bun-shaped or tending to still flatter forms. I find it difficult to imagine that a river current is more likely to give a rotary movement to pebbles than a journey through a tube-mill, and as far as can be judged without actual experiment, the shape of the pebbles is more dependent upon the original shape of the fragment and on the material of which it is composed than upon other factors.

I am informed that many of the pebbles formerly imported into this country for use in tube mills and which are remembered for their exceptionally rounded forms were obtained from the coast of France, between Boulogne and Dunkirk, and not as might have been expected from a river deposit.

With regard to the occurrence of large pebbles in the Ferreira Deep referred to by Dr. Young, the original exposure in the drive certainly suggested the idea that the body of large pebbles there seen, formed part of the Main Reef Leader. The relation of the large-pebbled body to the Leader was, however, far from clear. Subsequent stoping operations by which the body of large pebbles and the Leader proper were followed for a considerable distance clearly showed that the former occupied a position below the Leader, and was entirely distinct from it. The large-pebbled material had in fact a similar relationship to the Leader as that shown by several occurrences of large-pebbled banket in various other localities described in my paper on the Upper Witwatersrand System.* The great contrast between these erratic and variable pebble masses and the constancy and persistency of the Leader over nearly fifty miles of country as well as the manner in which the Leader cuts off the bedding of such bodies and continues its own course without interruption is indeed one of the principal grounds for regarding the Leader as having been laid down in a somewhat different manner from the underlying beds. These erratic bodies of large pebbles appear to occur among material which fills channels cut in the surface over which a wide spreading current subsequently deposited the material which now constitutes the Leader.

The presence of large pebbles of soft schistose rock referred to by Dr. Young, which he regards as affording clear evidence that ancient schists were being subjected to denudation somewhere in the vicinity, and which he considers show a marked resemblance to rocks of the Swaziland system, is capable, I think of a very different and more probable explanation. In 1912, when I saw the occurrence referred to by Dr. Young, and collected specimens of the soft schistose "pebbles," I had seen nothing similar and to me also they suggested fragments of older schistose rocks. Since that time, however, at Kleinfontein and elsewhere I have met with numerous examples of inclusions of almost exactly similar material in the conglomerates under such circumstances as to leave no doubt in my mind that they are fragments derived by contemporaneous erosion from the partially consolidated muds upon which the Main Reef Leader was deposited.* In general appearance as well as in respect to such qualities as colour, hardness, etc., these included fragments at Kleinfontein are closely similar to those at the Ferreira Deep, and in my opinion both occurrences are similar in origin. With regard to the soft schistose fragments at the Ferreira it must be remarked that several examples which I saw could scarcely be called "pebbles," but were irregular sub-angular fragments with ill-defined outlines such as might be expected from the mode of origin suggested above. Although a schistose structure is comparatively rarely shown by the conglomerate itself the "slate" footwall immediately below it frequently takes on a character precisely similar to that shown by the fragments included in the Leader. This is almost certainly an effect produced after their inclusion in the conglomerate, as is also the development of chloritoid and sericite.

---

*Trans. Geol. Soc. S.A., Vol. xviii., 1915, pp. 26-30 and figs 3 & 4

Dr. Young's reference to Swaziland rocks and his view that the soft schistose fragments in the Ferreira Deep occurrence were originally pebbles of older schist carried but a short distance from their source by a small current indicates that he shares the opinion held by many others, including Prof. Gregory, that at the time of the deposition of the Main Reef group of conglomerates there exised a shore line of ancient rocks in close proximity to the locality occupied by the present line of outcrop of the Main Reef. This view appears to me to leave out of account altogether the important evidence available from the character of the beds found below the Main Reef and from the whole of the earlier history of the Witwatersrand system. It must be remembered that the series of coarse sandy and gritty beds, among which the Main Reef conglomerates occur, grade downwards into a thick series of predominantly fine-grained deposits over 3,000 ft. in thickness (the Jeppestown Series). These are known to be continuous in an east and west direction for at least 50 miles without any very great variation in thickness. Their original extent therefore from east to west may easily have to be reckoned in terms of hundreds of miles, as is certainly the case with many other members of the Lower Witwatersrand system, and there is no reason to believe that their extension in a north and south direction was very different. This means that during the deposition of the Jeppestown Series anything in the nature of a pronounced shore-line of older rocks must have been very remote from the present site of the Rand. Subsequently there was probably an advance of the land surface towards the area in which the Witwatersrand system was being deposited, but this process was a very gradual one, and there was again a return to the earlier conditions at the time of the deposition of the Kimberley Shales. I find it extremely difficult to imagine the geographical conditions under which a formation presenting the features shown by the Jeppestown and Main-Bird Series could have been laid down if a shore-line of older rocks existed anywhere near the present site of the Rand, as is considered to be the case by Young, Gregory and others.

With regard to the further point raised by Dr. Young concerning the persistence of individual bands of conglomerate in the Kimberley Series over a distance of a mile or more, this is in my mind a very different thing to persistence of the Main Reef Leader over a distance of at least 45 miles in one direction, and probably over 50 miles in a direction at right angles to that. The conditions necessary to account for the two cases appear to be extremely different. One can easily imagine how the more persistent members of the Kimberley Reefs may owe their origin to the working over of confusedly-bedded gravels by the waves as suggested by Dr. Young, but it is not easy to see how the same agency could have produced a pebble bed like the Main Reef Leader, extending over hundreds of square miles of underlying muds as would have had to be the case in the Far East Rand. This is one of the many examples in which explanations which seem sufficient if only the Central Rand is considered appear totally inadequate when the problems of the Far East Rand are also taken into account.

In connection with the origin of the gold in the conglomerates surprise is expressed that I have not given prominence to the bearing on this question of the banded pyritic quartzites associated with the conglomerates. The significance of these banded quartzites was however discussed at some length in my paper, on p. 173, under the head of "Secondary Changes." Like Dr. Young, I regard them as very

---

†*Trans. Geol. Soc.* **S.A.**, Vol. xviii., 1915, p. 51.

important evidence in support of the detrital origin of the gold. The photograph accompanying Dr. Young's discussion gives an excellent idea of the character of the pyritic bands, and their significance is still more apparent when, as is often the case, their distribution agrees closely with all the details of current-bedding and other structures dependent on sedimentary agencies.

Mr. J. S. Curtis, in opposing the view that the gold in the conglomerates is of detrital origin, says " Investigations of gold-quartz veins have not yet determined the reason for gold solutions taking any particular course, and if there has been no general rule discovered governing the distribution of the ore in quartz lodes, why should such an explanation be demanded for the ore-bodies in the banket?" It is precisely the fact that in the case of the conglomerates, we can in many instances give an explanation for the distribution of the gold, and that such explanations are almost universally closely associated with sedimentary features, that will appear to many to be evidence of the strongest character for the sedimentary origin of the gold and against the inclusion of the banket among lode deposits.

Mr. Curtis objects to a comparison of the Rand conglomerates with more recent formations, such as the Nome gravels, on the ground that the former are traversed by abundant igneous rocks and that the latter are not. Surely such an argument would debar us from innumerable other comparisons of older rocks with recent deposits to which geology as a science owes its very foundation. The continued fascination which igneous rocks appear to have for those favouring the secondary origin of the Rand gold is very remarkable in face of the abundant and ever accumulating evidence against any connection between the gold and the igneous rocks associated with the Witwatersrand system whether of contemporaneous origin or later intrusions.

In the case of the former the conglomerates most likely to be affected by them are among the least auriferous, and in the case of the latter the thousands of instances one meets with in the mines where one might reasonably expect positive evidence in favour of the influence of such intrusions on the distribution of the gold, and where no such evidence is to be found constitute a continually increasing mass of evidence against these igneous rocks having anything to do with the introduction of the gold into the banket.

Mr. Curtis regards as evidence in favour of the lode origin of the Rand gold the fact that all the conditions favourable to the formation of lodes are present on the Rand. This is quite true, and mineral veins are of frequent occurrences throughout the area. The extraordinary thing, however, about these veins is that although they have been extensively prospected none has been discovered, especially in the Upper Witwatersrand system, in any way remarkable for its gold content, and the great majority are altogether barren. In the few instances in which they have been found to contain any values, the gold can in many cases be clearly seen to have been derived from auriferous bankets traversed by the vein and it is limited to the immediate neighbourhood of such a source.

THE ENCOURAGEMENT OF FIRST AID WORK ON THE MINES: SOME SUGGESTIONS BASED ON CROWN MINES EXPERIENCE.

By A. J. Brett.

(Printed in Journal, June, 1916.)

DISCUSSION.

The President: This paper deserves a hearty welcome, since it is the first which has so far appeared here on this subject, and it comes most appropriately from the General Manager of the mine which has been foremost in its encouragement of first aid work on the Rand.

The scheme adopted is simple, cheap, and apparently effective: but no matter how simple or otherwise, the only standard, by which it can be judged, is its efficiency in actual practice, in other words, its total effect in bringing safety and succour to underground humanity. Criticism is almost disarmed by the author's modesty and by the absence of definite data, which is extremely unfortunate, a fact which the author himself deplores, but does not shrink from the declaration, that the scheme adopted is thoroughly satisfactory. This is a state of affairs, which should, on the one hand, surely lead to increased interest and further progress being achieved on the mine itself, and on the other hand, the initiation of similar methods on other mines, where first aid is at present little more than a pious expression of opinion, symbolised by an out of date disused stretcher.

The first point in the scheme outlined is the appointment of a Chief Ambulance Officer, as the executive head of the organisation, and in this case the hospital orderly was called upon to do the work. This, I venture to think, is an excellent practice, provided that the hospital orderly be skilled also in practical first aid work, and at the same time gifted with the power of instructing and thereby arousing the enthusiasm of others, in order that all demands can be efficiently met, when the necessity should arise. The two offices should however be kept distinct, in the sense that they should bear a distinct and separate remuneration, and this should be specifically stated or arranged, in order to avoid misunderstanding, and at the same time, to impress the need for constant vigilance and efficiency. In mines where accidents are of seldom occurrence, there are distinct tendencies to shirk first aid practices with unhappy results at the moments when they do occur, and it is to prevent this, that the above suggestion is put forward again.

With regard to equipment this should be generous, and, as far as possible, of the best kind. Standardisation would be valuable for the reasons given, as far as the Rand is concerned, where migration is so prevalent, but on the other hand, it is of greater importance to be provided with some equipment and a full knowledge of its use.

The need for sub-officers, one at each shaft is obvious and indispensable, in order that no time be lost, when notice of an accident has been received, and for this purpose also these officers must have in their possession a complete equipment, which should be inspected weekly by the Chief Ambulance Officer, to insure its being always in order.

The arrangement of first aid stations and equipment underground should be made by the Chief Ambulance Officer, in consultation with the underground officials, assisted by a committee chosen by the miners themselves, and its care should be the direct responsibility of the latter. If the men themselves are thus given a share in the work, much more interest and keenness will be manifest, than if the entire control and initiative springs from above.

The payment of bonuses is theoretically correct, but no statement is made as to how it is ascertained whether these payments are commensurate with the value received, other than the dictum. that every patient who has suffered by an accident comes to hospital having received thoroughly efficient first aid treatment. This is excellent testimony, as far as it goes, but there are other factors, which should be given consideration, as all those, who have taken part in or even only witnessed Ambulance Competitions, can readily testify. The only real test of first aid work is at the periods when accidents do actually occur, and I venture to think that the tests of efficiency of any system of ambulance work, or of any team, or indeed of any member of the team, should be applied then. This could easily be done by means of a full enquiry, carried out by the medical officer and one or two of the chief officials. Should the result of this enquiry demonstrate excellence, suitable rewards could be made, either to the team or to individual members thereof. On the other hand, good work would prove that the payments had not been made in vain, and the enquiry would also at once discover, if there were any weaknesses, which necessitated remedial measures being taken. Ambulance competitions are most excellent stimulants and aids, educationally speaking, to success in ambulance work, but they are incapable of deciding, which particular team of men would prove most efficient. if an actual call were made.

The system of bonuses as applied to lectures and certificates is also an excellent means of cultivating interest, and the letter reproduced by the author amply proves its justification. The suggestion, that laymen who have made a study of first aid work should co-operate as judges in ambulance competitions, along with the medical men, is a good one, and with the author, I hope that this will meet with approval from all sides. It is refreshing to learn that the knowledge of the inner meaning of the accidents possible to those engaged in mining, has been verified by Crown Mines' experience, in other words, that safety first and first aid are necessarily cognate and allied branches of the science of the conservation of human life. It is also a matter for congratulation that the mine officials take an interest in the work, and so attempt to lead their employees by precept and good example. This also may be viewed from another point and the analogy holds good, namely, that in warfare against nations a soldier may risk his own life, if he chooses, but his code of honour does not allow him to expose his fellows to undue and unnecessary risk. Should not this code apply to all mine officials as well as to the employees, Government officials and others, whose duties are in the mine itself? The progress and solution of the problems of sociology prove that its universal application is now merely a matter of time. There are, I venture to say, no underground workers who would not at once subscribe to the principle, but on the other hand I fear that there are many with whom it is not much more than a pious opinion rather than a practice of daily use and vigilance, such as safety first and first aid should be.

Nothing is stated in the paper about practice and team work or the encouragement to be given to new ideas, as far as ambulance work is concerned. The former can be effected by organising Ambulance Corps under Red Cross rules, which have been specially framed for this purpose. For the latter, the committee of the Ambulance Corps, along with co-opted members, would form a suitable board for adjudication purposes to carry out tests and recommend such awards to the directorate and management, as would be appropriate in each particular instance. Several cases of this kind have come to my notice, but unfortunately for various reasons, it has been impossible to deal with them, since the cessation of the annual exhibitions and competitions held by this Society. Local encouragement on the mine itself should be given to the mine workers, if only to stimulate thought, and thereby create interest. The author's views on this phase of first aid work would be welcome.

The title of the paper is given as the encouragement of first aid work on mines, the object is stated to be to arouse increased interest, and the hope is expressed that it will arouse discussion. In pursuance of these aims, I venture to think that it might be of some utility to mention what is being done in this respect in the United States of North America. By way of preface it is necessary to state that the work performed there is primarily and especially for coal miners, to whom the dangers of explosions resulting from the presence of coal dust, hydrides and oxides of carbon, mixed with the necessary proportions of air are ever present, and which may entail a serious loss of life, in many cases endangering the life of every underground worker, most of whom, if not all, are white men. Although the mines here have not this menace to contend against, yet I hope that a brief description of the methods adopted will not be lacking in instructiveness and assistance in solving our own problems.

In the first place it should be stated that the Federal Government has made it a separate department of the work of the Bureau of Mines in conjunction with the work connoted by the term "Safety First." In addition to this, many of the larger mines have taken up the work individually for the sake of their employees. The Mines Department works hand in hand with the American Red Cross organisation, which is also supported largely by funds from the Federal Government, and hence is capable of undertaking a large sphere of work. The functions of these organisations are in the first degree of an educational character, and no means are spared in their fulfilment. It would be beside the point, and it is far from my intention, to enter into any arguments as to whether works of this nature should be performed by the State or by individuals, since I believe, that the care of the human element is everybody's concern, and is at the same time a good investment all round.

Briefly the work so far undertaken may be summarised as follows:—

1. National mine safety demonstrations.
2. Provision of mine rescue touring cars.
3. Establishment of museums of safety appliances.
4. Provision of moving pictures for exhibition.
5. Liberal and free distribution of bulletins and pamphlets.
6. Official reports of tests of new safety and first aid apparatus carried out by the Federal Scientific Department,
7. Educational work on sociological problems, *e.g.*, the use and abuse of alcohol, etc.

The first National Mine Safety demonstration, which may be taken as typical, took place at Pittsburgh on October 30th, 1911, under the auspices of the U.S.A. Bureau of Mines, the Red Cross Society and the Pittsburgh Coal Operators' Association (*vide Scientific American*, Dec. 2, 1911, Vol. 105, p. 498). The various items of the demonstration were as follows:—

(*a*) Exhibition of a testing gallery, 100 ft. long × 6½ ft. diameter, open at one end and closed at the other, made of steel provided with side windows through which the flame of an explosion is visible, and doors on the top which are raised by the force of an explosion.

(*b*) Test of explosives in the gallery by exploding known weights of known mixtures from the closed end in an explosive mixture of known composition (*e.g.*, 7%—8% CH_4 and C_2H_4 and 92%—93% air.) By using the same weight the explosibility of different atmospheres can also be tested).

(*c*) Exhibition of the actual use of various types of breathing apparatus by men wearing them in rooms having glass partitions and filled with noxious gases.

(*d*) Tests on safety lamps.

(*e*) The use of apparatus for testing explosives.

(*f*) Exhibition of mine rescue cars.

(*g*) Ambulance team competitions (40 teams competing).

(*h*) Demonstration of the explosibility of coal dust in the experimental mine of the Federal Bureau of Mines.

(*i*) Demonstration of the use and action of CO on canaries.

(*j*) Exhibition of the methods of protecting electric motors in mines showing that the removal of the protection will cause explosions.

(*k*) Methods of taking gas samples.

(*l*) Fuel briquetting plant to show better utilisation of low grade fuels.

Mine rescue cars are railway coaches fitted up for completely housing a team or teams of miners, specially versed in first aid and rescue work, and officials, and a complete equipment of all kinds of apparatus, including spares, with a work bench for repairs. Electric current is provided by storage batteries, giving any voltage required. They tour the States where mines are located, and visit the mining camps, making a stay at each one with the object of giving instruction, and arousing interest in first aid work by organising local teams.

The rest of the work mentioned is self-explanatory.

The question now arises whether we can gain anything from this knowledge of what is being done in the American Coal Mines. Their problems are to a great extent very different to those here, but I venture to suggest that a first aid meet or a mine safety demonstration on a large scale, showing how to solve our own difficulties would be of great benefit to the Rand, if only to encourage more interest being taken in the work than is the case at present. Also the provision of a permanent museum, a section of which could be devoted to an exhibition of safety appliances open to the public would be a progressive step for this community to take. At present Johannesburg lacks this advantage, which is possessed by most of the other large towns in the Union, and should provision be made at any time in the near future, a section of this nature should not be overlooked.

Since gassing accidents are not by any means a rarity on these fields, and their first aid treatment involves the production of artificial respiration, the mechanical devices, which have been used successfully in America, and reported as quite efficient, namely, the pulmotor, lungmotor and viamotor might also be investigated here.

The proximity of the mines on the Rand does not, in my opinion necessitate the provision of touring cars, provided that each mine possesses a skilled Ambulance Officer and a liberal equipment.

In conclusion, it is my hope that the author's paper will remove to a large extent the apathy and indifference which has hitherto been shown in this important matter in many quarters, more especially on our coal mines, and encourage an interest in both the work of safety first and first aid, before the cry should arise "too late!" Efficiency and cheapness are two magic words to apply to-day to any scheme and these alone should commend the Crown Mines' methods to the notice of all who for the sake of humanity have similar problems to tackle.

Note.—A number of slides illustrating the above remarks on work undertaken in America were shown.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Determination of the Hardness of Water using Methyl Red as Indicator.—After discussion of older methods such as the Clark soap test and the Otto Hehner alkalimetric method, the authors suggest the new method of titration of both kinds of hardness, based on the use of methyl red as indicator.

Methyl red is yellow in a neutral solution, *i.e.*, when the concentration of hydrion is about 10^{-7} normal, and it becomes red when the hydrion concentration rises to about 10^{-5}, or one hundred thousandth normal. Methyl orange on the other hand, does not begin to appear red until the acidity of the solution is more than ten times greater, *i.e.*, about 10^{-4} normal. In practice, this means that methyl orange changes colour comparatively slowly and that there is an uncertainty in the end-point of an ordinary titration amounting to at least 0·5 cc. of $N/100$ acid; whereas, using methyl red, a single drop of $N/100$ acid is sufficient to decide the end-point. Methyl red is more sensitive to carbonic acid than methyl orange, and in the titration of carbonates and bicarbonates the solution must be heated to boiling in order to remove carbon dioxide. Methyl red may be used with advantage in place of methyl orange for all ordinary purposes in volumetric analysis. It is very much better than methyl orange for titrating ammonia or solutions containing ammonium salts, as, for example, in the Kjeldahl determination of nitrogen. Methyl red can also be used in artificial light with far less difficulty than methyl orange.

The determination of 'temporary' hardness or, more correctly, of bicarbonate hardness, is carried out as follows:—Measure 100 cc. of the water into a porcelain casserole and add 2 cc. of methyl red solution (0·05 gm. dissolved in 1 litre of 80% alcohol). Run in $N/50$ hydrochloric acid until the liquid becomes light red. Heat to boiling, boil for about one minute, and continue the addition of standard acid until a permanent reddish tinge, which is not destroyed by further boiling, is obtained. An alternative method of procedure, which is more convenient and expeditious is to add a slight excess of acid (about 1 cc.) and then after boiling for about one minute, to titrate back with $N/50$ baryta solution.

It is inadvisable to boil the water before beginning the titration, because crystalline calcium and magnesium carbonates, which may be precipitated on boiling a hard water, interact very slowly with the dilute standard acid. Should there be any objection to boiling the water, the titration may be carried out at the ordinary temperature by adding excess of acid and passing a current of air through the liquid for a few minutes in order to remove the carbon dioxide.

Each cc. of standard acid required for 100 cc. of the water corresponds to 1 part of calcium carbonate in 100.000 or 1° of hardness. Some natural waters contain sodium carbonate, and the 'alkalinity' may be due partly to the latter. In that case a correction referred to under 'permanent' hardness must be applied.

'Permanent' Hardness.—The determination is carried out as follows:—In a platinum basin mix 100 cc. of the water with 10 cc. of $N/25$ potassium carbonate. (If the 'permanent' hardness is believed to exceed 15°, more potassium carbonate must be used). Evaporate to dryness on the steam-bath. Pour 10 cc. of 20% alcohol into the basin and bring the liquid into contact with the whole of the residue. Replace the basin on the steam-bath until the liquid is hot again, and then filter through a 5½ cm. paper, receiving the filtrate in a casserole or flask of resistant glass. Rinse the basin very carefully four times with cold 90% alcohol, using about 5 cc. each time, and then wash the filter five times with the same alcohol. Titrate the filtrate with $N/50$ hydrochloric acid, using methyl red as indicator, as described under 'temporary' hardness and substract from 20 cc., the amount due to the K_2CO_3 used, the difference being degrees of permanent hardness. The platinum basin and the filter, containing the precipitated carbonates of calcium and magnesium, are set aside for the determination of total hardness.

If the original water contained sodium carbonate, there can be no 'permanent' hardness, and in the foregoing determination more alkali will be found in the filtrate than was added to the water as potassium carbonate. The excess of alkali represents the amount of sodium carbonate present in the water, and it must be deducted from the 'alkalinity' of the water in order to ascertain the actual bicarbonate hardness.

Other modifications of the process are suggested and the paper is well worth careful perusal.—S. A. Kay, D.Sc. and S. H. Newlands, M.A.—*Journal Soc. Chem. Ind.*, April 29, 1916, pp. 445-7. (A. W.)

N.B.—We have tried this process and recommend it is an improvement on earlier ones. There is, however, some apparent difficulty in obtaining the indicator. (Ed. Com.)

Rapid Qualitative Determination of Tungsten. "Tungsten determination by a quick method is that of W. L. Faust of Deadwood, South Dakota. He uses a fusion-powder containing potassium chlorate, potassium nitrate, sodium carbonate, and sugar. Taking about 1 gm. of this powder, mixed with an equal amount of crushed ore (if the ore is low grade using pannings) an almost instantaneous fusion is effected by applying a match. The result of the fusion is a granular mass, which is rubbed a moment in an agate mortar, then placed in a test-tube with hydrochloric acid and sheet or granulated zinc. A little boiling will yield a blue-coloured solution if tungsten is present. The test is one that can easily be made in the field: the equipment necessary to conduct it can be carried in a coat-pocket and it no doubt will be widely used by prospectors."—W. L. Faust.—*Mining and Scientific Press*, April 8, 1916, p. 523. (G. H. S.)

Melting Points and Other Standard Temperatures.—"The following tables are reproduced from Circular No. 35 (second edition) of the United States Bureau of Standards as they should prove exceedingly handy for use.

The values of the melting points used by the Bureau of Standards as standard temperatures for the calibration of thermometers and pyrometers are indicated in capitals. The other values have been assigned after a careful survey of all the available data.

As nearly as may be, all values, in particular the standard points, have been reduced to a common scale. For high temperatures, and for use with optical pyrometers, this scale is satisfied very exactly by taking $c_2 = 14{,}500$ in the formula for Wien's law connecting I, monochromatic luminous intensity of wave length λ, and T, absolute temperature: $\log I/I_1 = c_2 \lambda \log_e \quad (1/T_1 - 1/T)$. For all purposes, except the most accurate investiga

MELTING POINTS OF THE CHEMICAL ELEMENTS.

ELEMENT.	C	F
Helium	< −271	<−456
Hydrogen	−259	−434
Neon	−253?	−423
Fluorine	−223	−369
Oxygen	−218	−360
Nitrogen	−210	−346
Argon	−188	−306
Krypton	−169	−272
Xenon	−140	−220
Chlorine	−101·5	−150·7
MERCURY	− 38·9	− 38·0
Bromine	− 7·3	+ 18·9
Caesium	+ 26	79
Gallium	30	86
Rubidium	38	100
Phosphorus	44	111·2
Potassium	62·3	144
Sodium	97·5	207·5
Iodine	113·5	236·3
Sulphur	S_{I} 112·8 S_{II} 119·2 S_{III} 106·8	235·0 246·6 224·2
Indium	155	311
Lithium	186	367
Selenium	217-220	422-428
TIN	231·9	449·4
Bismuth	271	520
Thallium	302	576
CADMIUM	320·9	609·6
LEAD	327·4	621·3
ZINC	419·4	786·9
Tellurium	452	846
ANTIMONY	630·0	1166
Cerium	640	1184
Magnesium	651	1204
ALUMINIUM	658·7	1217·7
Radium	700	1292
Calcium	810	1490
Lanthanum	810?	1490
Strontium	>Ca<Ba?	...
Neodymium	840?	1544
Arsenic	850?	1562
Barium	850	1562
Praseodymium	940?	1724
Germanium	958	1756
SILVER	960·5	1761
GOLD	1063·0	1945·5
COPPER	1083·0	1981·5
Manganese	1260	2300
Samarium	1300-1400	2370- 2550
Beryllium (Glucinum)	1350?	2462
Scandium	?	...
Silicon	1420	2588
NICKEL	1452	2646
Cobalt	1480	2596
Yttrium	1490	2714
Chromium	1520	2768
IRON	1530	2786
PALLADIUM	1549	2820
Zirconium	1700?	3090
Columbium (Niobium)	1700?	3090
Thorium	>1700 <Pt.	>3090 <Pt.
Vanadium	1720	3128
PLATINUM	1755	3191
Ytterbium	?	...
Titanium	1500	3272
Uranium	<1850	<3362
Rhodium	1950	3542
Boron	2200-2500?	4000-4500
Iridium	2350?	4262
Ruthenium	2450?	4442
Molybdenum	2500?	4500
Osmium	2700?	4900
Tantalum	2850	5160
TUNGSTEN	3000	5430
Carbon	>3600 for p=1 At.	>6500 for p=1At.

OTHER STANDARD TEMPERATURES.

Substance.	Phenomenon.	C	F	Variation with pressure (pressure in mm of Hg)
OXYGEN	Boiling	−183·0	−297·4	$C° \quad - 183{\cdot}0 + 0{\cdot}01258\ (p - 760) - 0{\cdot}0000079\ (p - 760)^2$
CARBON DIOXIDE	Sublimation in inert liquid	− 78·5	−109·3	$C° = - 78{\cdot}5 + 0{\cdot}017\ (p - 760)$
SODIUM SULPHATE $Na_2SO_4 + 10H_2O$	Transformation into anhydrous salt	32·384	90·291	
WATER	Boiling	100	212	$C° = 100 + 0{\cdot}03670(p - 760) - 0{\cdot}00002046(p - 760)^2$
NAPHTHALENE	do.	217·96	423·73	$C° = 217{\cdot}96 + 0{\cdot}058(p - 760)$
BENZOPHENONE	do.	305·9	582·6	$C° = 305{\cdot}9 + 0{\cdot}063(p - 760)$
SULPHUR	do.	444·6	823·3	$C° = 444{\cdot}6 + 0{\cdot}0908(p - 760) - 0{\cdot}000047(p - 760)^2$
Ag_3Cu_2	Eutectic freezing	779	1434	
SODIUM CHLORIDE	Freezing	801	1472	

tions, the thermodynamic scale is identical with any of the gas scales.

At high temperatures some of the values are quite uncertain; thus, while the melting point of platinum may be considered accurately known to 5° C., that of tungsten is uncertain by 100° C. or more. Temperatures centigrade are rounded off, and the exact Fahrenheit equivalents are usually given."—United States Bureau of Standards.—*Metallurgical and Chemical Engineering*, May, 1915, p. 302. (G. H. S.)

Electro-Chemistry in the United States.—"The Niagara Falls section of the American Electrochemical Society in February discussed the development of power from the Falls in connection with the electro-chemical industries. According to *Metallurgical and Chemical Engineering* complaints were made with regard to the restriction of power development at Niagara by the United State Government. It was stated that the Niagara Falls Power Company generated 90,000 h.p., and the Hydraulic Power Company, 100,000 to 125,000 h.p., all the latter, except 15,000 h.p., being employed in the electro-chemical industries. Mr. F. J. Tone said that the year 1915 had taught them that a nation must be economically and industrially independent and self-contained. Crude potash, formerly obtained from Germany, had risen from £7 to £80 per ton; ferro-manganese, derived from England, had been placed under embargo, and its price had risen from £7·6 to £25 per ton, while many commodities had become almost unobtainable. Few realised to what extent their great basic American industries depended upon electrochemistry, particularly the electro-chemical products of Niagara power. Steel manufacture, the greatest of all American industries, was absolutely dependent upon Niagara power for ferro-alloys; ferrosilicon was an essential element in the production of 15 million tons of steel; ferro-chromium, ferro-tungsten, and ferro-vanadium were indispensable to the manufacture of highspeed tool steel, while ferro-chrome was the hardening element in armour-plate and armour-piercing projectiles, and electrical transformer steel was equally dependent upon the products of Niagara power. Artificial abrasives to the amount of 20,000 tons a year were produced at Niagara and were indispensable to many industries; aluminium and calcium carbide were the largest of the electro-chemical industries at Niagara; nitrogen fixation works had been established on the Canadian side of the river, but employed only 25,000 h.p., whereas in Europe over 300,000 h.p. was devoted to the production of nitrogen fertilizers. For the spectacle of Niagara they were paying the price of a million tons of coal a week. It was stated that from 125,000 to 150,000 h.p. was transmitted into the United States from the Canadian side, and that the continuance of this supply depended upon permits revocable by the Canadian Government. The generation of large quantities of additional power at Niagara on the American side was the only way to avoid a 'frightful dislocation of American industry.' The development of the electro-chemical industries has been the salvation of Germany and should equally be undertaken by the United States as a matter of preparedness in national defence."—*Indian Engineering*, May 27, 1916, p. 319 (J. A. W.)

Solanaceous Drugs from Africa.—"The following percentages of total alkaloid, calculated on the dry material, were found in samples of African solanaceous drugs:—*Hyoscyamus muticus*, Linn., from Sudan, mixed leaves and stem, 0·77%. *Datura Stramonium*, from Egypt, stems and fruits, 0·138 ; leaves, 0·32%. From Sudan, mixed stems, leaves, and fruits, 0·13%; seeds, 0·096%. From South Africa, leaves, 0·54%."—*Bull. Imp. Inst.*—*Journal of the Society of Chemical Industry* June 30, 1916, p. 706. (J. A. W.)

METALLURGY.

Crushing and Grinding.—"*Primary Crushing.*—In a recent paper Mr. George Bradley described a crushing plant to handle 1,000 tons per day of an average ore, reducing from run-of-mine to a point where all passes 0·25 in. aperture. This combination of gyratory crushers and rolls is not at present in general use in preparing ore for cyanide treatment, and there seems little reason to doubt that it will play an important part in the preliminary crushing of the very large low-grade deposits which are rapidly assuming importance in the metallurgy of gold and silver.

Where the adjuncts of very large-scale operations are available, dry crushing with gyratory or jaw crushers, followed by rolls down to 0·2 in. aperture stands in a class by itself, so far as costs are concerned. Such equipment is not well adapted, however, to the usual cyanide mill operations. The incidental problem of dust is also one to which the cyanide metallurgist will be wisely loth to revert.

The trend of recent practice is strongly toward two-stage primary crushing, using first a large-size Blake-type or jaw crusher, located either underground or at the surface, depending on the system of mining employed, and breaking from run-of-mine to, say, 6 in. ring. This product is re-crushed in cone crushers to, say, 2 in. ring, suitable trommels or grizzlies being provided to eliminate undersize material from the feeds, but neither machine being operated in a closed circuit. Dry crushing is not usually carried beyond this point.

The Symons horizontal shaft disc machine is a recent development in crushing practice and is giving excellent results in breaking from 4 in. to 6 in. ring down to 1 in. or 2 in. ring, as a preliminary to further reduction in stamps, Chilean mills, or small ball mills. Undersize material should be carefully removed from the feed of this machine, either by impact screens, trommels, or inclined stationary screens (not by grizzlies). Maximum efficiency will only be obtained by operating in closed circuit, returning the product to the eliminating screen. These crushers unquestionably have a wide range of application, particularly on hard, brittle ores, but are not adapted to wet, sticky ores or those which contain large pieces of tough schist or gouge.

As illustrating the range in cost of coarse crushing in the average cyanide plant, may be taken the figures from the 1914 Annual Reports of the four following companies, which are representative of modern American practice:

Goldfield Consolidated, Nev., crushing and conveying	$0.046
Belmont Milling Company, Nev., crushing and conveying	0.068
Commonwealth Mine, Arizona, crushing and conveying	0.079

Hollinger Gold Mines, Porcupine, crushing and conveying 0.113

Fine Crushing or Coarse Grinding.—Either of the above designations may be taken to cover the reduction of an ore from approximately 1½ in. or 2 in. ring to 0·25 in. aperture, depending upon whether the energy is applied by impact or attrition, or by both.

The gravity stamp, crushing by impact, is probably used in 95% of the cyanide plants throughout the world. Much has been written and more has been said of the faults of this machine; in particular, the high installation cost, especially in foundations and bin construction, the low power efficiency, and last but no means least, the excessive noise. And most operators will testify that its sins have not been exaggerated. But in spite of all this it has also some most excellent virtues, inasmuch as it will crush any kind of ore from clay to chert and can be adapted to any size unit construction. Also men skilled in the operation of stamps may be found in every mining district of the world, although even this point is not vital, since the machine is so nearly fool-proof.

There is, however, at the time, a decided tendency in American and Canadian practice to supplant the stamp with the newer types of ball mills, and it is the authors' belief that in the future, few, if any, new stamp mills will be built on the American continent. Whether this development will extend to other countries remains to be seen, but such would appear to be the logical outcome of the excellent results now being obtained.

The practice of crushing with stamps to a finished product for cyanide treatment has now become obsolete except in a very few instances. Even the strongest adherents to stamps now admit that the final reduction should be made in some type of attrition mill, irrespective of the ultimate fineness desired.

Excepting only the increase in weight and the strengthening of individual parts to meet this increase, the gravity stamp as built to-day differs little from the California practice of thirty years ago. Concrete mortar blocks have replaced the former timber pile foundation, and the battery framing is, of necessity, much heavier and stiffer to stand the excessive vibration of a falling weight varying from 1,250 lb. to 2,000 lb.

The economic limit of battery screen aperture in modern plants is now considered to range from 0·15 in. to 0·4 in. This statement will apply either to the so-called 'all-slime practice' (70% or more through 200 mesh 0·0029 in.) in America and Mexico, or to the comparatively coarse grinding (95% through 65 mesh, 0·0082 in.) obtained upon the Rand.

Stamp-mill practice has reached its highest development in the Transvaal, and this is a logical result, when one considers the magnitude of operations within the limited area and the keen rivalry existing between the men in charge of the operations of the various groups. Also the assured life of the plants amply justifies large capital expenditures to obtain low operating and maintenance charges. Since the introduction of the tube mill, stamps have increased in weight up to 2,000 lb. each, but at this point the economic limit seems certainly to have been reached, and many prominent metallurgists hold to the view that, all things considered, the practical limit for a five-stamp battery is reached at about 1,600 lb. falling weight.

In 1911, competitive trials were carried out in one of the Rand plants to compare the work of the standard five-stamp battery and the Nissen, or single-unit stamp. These trials are said to have shown one-third greater capacity per pound of falling weight, and an equal gain in efficiency, in favour of the single-unit type. It is, however, significant that of the six new plants built on the Rand since these trials were made, only one proposes to make use of the new type.

The cost of stamp milling on the Rand naturally varies between wide limits, depending chiefly upon the tonnage crushed and upon the ratio of stamps to tube mills. In the modern plants, the total charge against stamp milling does not exceed 20 cents per ton crushed, and the mills built within the last year are probably even a little under this figure, truly remarkable result when one considers that the Rand banket is probably the hardest gold ore milled anywhere in the world. The average cost is, of course, above these figures, being, in 1913, 29·3 cents for thirty of the larger plants.

The following table gives the essential data of American stamp-milling practice, under widely varying condition, both in the nature of the ore handled and the tonnage milled :—

TABLE I.—STAMP MILLING DATA.

PLANT.	Tons Milled 24 Hours.	Number of Stamps	Running Weight	Discharge Aperture	H.P. Hours P.T. Milled.	Stamping Cost Cts. P.T. Milled.	Sizing % —00 (0·0055 in.)	Sizing % —200 (0·0029 in.)
Mexico Silver Mill	1000	60	1450	0·371	4·8	10·0	...	14·0
Nipissing ...	245	40	1450	0·334	12·1	23·8	20·3	16·7
Belmont ...	500	60	1200	0·131	7·2	20·7	28·3	19·5
Silver Peak ...	500	120	1050	0·023	13·8	31·4	54·0	40·0
Homestake ...	4500	1020	850	0·022	11·0	20·4	80·0	60·0
Hollinger ...	585	60	1400	0·263	8·6	16·0	...	15·0
Porcupine Crown...	150	20	1000	0·250	6·0	14·0	...	15·0
Liberty Bell ...	185	80	750	1·04	7·8	19·1	54·0	46·0

Fine Grinding.—The use of tube mills for final grinding to a finished product has now become almost universal in modern plants, whether for combined sand leaching and slime treatment, or for all-slime practice.

The classification or elimination of the finished products from the tube-mill feed has received particular attention and is recognized as vital for maximum efficiency. Cone classifiers, provided with diaphragms a few inches above the apex, are preferred where coarse grinding—say all to pass 65 mesh (0·0082 in.) is employed. This classifier has been developed on the Rand, and is universally used there with most excellent results.

In America, the general practice is to use mechanical drag classifiers of the Dorr, Akins, Esperanza or Ovoca types; with the closed circuit generally used, the tube mills discharge directly into the mechanical classifier, which not only effects the classification, but also elevates the oversize back to the tube-mill scoop feed.

The efficiency of a closed circuit in tube-mill grinding has been recently questioned in the technical press, but this contention is not borne out in practice: for not only is the principle almost universally used in tube milling, but it is also extending to other grinding and crushing machines —notably ball mills, roll, disc crushers, and even cone crushers.

Until quite recently, 38% to 40% moisture has been generally accepted as correct for the tube-mill feed, and this is probably true in so far as it applies to tube mills discharging within 6 in. of the central axis. With the introduction of peripheral discharge mills, however, much higher moistures will undoubtedly be found advisable, particularly for coarse grinding.

The theory of this new discharge, together with the companion problems of speed and moisture, are thoughtfully discussed in a recent paper by Mr. H. A. White—Bibliography (3),—and a careful study of his conclusions is recommended to those interested in the economics of tube milling. In particular, his proposal to operate the tubes at sufficient speed to maintain an automatically renewed lining of pebbles, brings up a most interesting line of thought, especially since the diameters of tube mills have already been increased to 8 ft. and 10 ft. in American practice, thus approaching the required peripheral speed to accomplish this result.

The proportion of tube-mill capacity to stamp capacity has gradually increased, until some of the new mills have as high as 4 cub. of grinding volume for each 100 lb. of running stamp weight. There is practically unanimous agreement that crushing and grinding costs have decreased substantially as more work has been thrown upon the tube mill, and a careful study of recent ball-mill practice leads the authors to conclude that some form of tube mill, or probably two mills in series, will ultimately eliminate the stamp.

The increasing difficulties experienced in obtaining satisfactory flint pebbles for grinding purposes have led to many independent investigations of the possibilities of steel or iron balls as substitutes. Hollow cast balls have been suggested and would seem to be logical for fine grinding, if practical to cast. Special polyhedron shapes are also being tried, with a view to reducing the interstitial spaces.

At one large mill in Northern Ontario, solid cast-steel balls up to 1½ in. diameter are being tried on a working scale, and, from results so far obtained, give promise of increasing capacity considerably in excess of the corresponding increase in power consumption, the latter being approximately 30% to 40%. It may be noted here that finely disseminated iron is no longer considered a serious detriment in cyanide treatment, and in any case, automatic electro-magnets will effectually remove the greater portion, if desired.

Another departure from standard tube-mill practice is the Marathon, or rod-mill. Iron or steel rods, from 1 in. to 2 in. in diameter, are substituted for the usual balls or pebbles, thus materially reducing the interstitial space and insuring a much more positive grinding. At a plant in Arizona, where this mill has been run parallel with Chileans and cone-end tube-mills, the results so far obtained indicate the possibility of valuable results from the further development of this principle.

Tube-milling costs on the Rand have, naturally, increased in the newer plants in proportion to the altered stamp-tube mill ratio, but on the other hand, stamping costs in the same plants have decreased the result being a net gain. Thus, newer plants show stamping and tube-milling costs to be almost equal, *i.e.*, from 18 cents to 20 cents per ton milled, or a total of from 36 cents to 40 cents; whereas average figures from some thirty plants show stamping at 29·3 cents and tube milling at 13·0 cents, a total of 42·3 cents. And even more important than this reduction in cost is the finer grinding—[5% +65 mesh (0·0082 in.) and 60% −200 mesh (0·0029 in.)] and, therefore, higher extraction obtained under the new conditions.

The following table gives the essential data of tube-mill operation in various plants in America :—

TABLE II. TUBE-MILLING DATA.

PLANT.	Tons Milled 24 Hours.	No. Tubes.	Dimensions of Tubes.	H. P. Hours P. T. Milled.	Cost P. T Milled.	Sizing Final Product.	
						% −100 (0·0055 in.)	% −200 (0·0029 in
Mexico Silver Mill	1000	6 6	5′ x 16′ 5′ x 20′	19·2	22·0	98·0	75·0
Nipissing	245	4	6′ x 20′	44·6	50·0	100·0	100·0
Belmont ...	500	7	5′ x 18′	16·8	40·9	99·0	72·3
Silver Peak ...	500	1	5′ x 18′	2·4	2·6	64·0	50·0
Homestake ..	4500	2 2	5′ x 14′ 5′ x 18′	0·8	1·2	87·0	66·0
Hollinger	585	6	5′ x 20′	16·0	18·8	100·0	90·0
Porcupine Crown..	150	1 1	5′ x 16′ 4′ x 20′	11·5	36·0	100·0	90·0
Liberty Bell ...	485	3	5′ x 22′	4·3	7·7	87·0	73·4

Stamps, Chilean Mills and Tube Mills.—This system of stage crushing and grinding is used at the Goldfield Consolidated mill in Nevada, and while the practice is almost unique, the excellent cost obtained are worthy of careful study. The equipment consists of one hundred 1,050 lb. stamps with 4 mesh (0·18 in.) screens, six 6 ft. Chilean mills with 30 mesh (0·012 in.) screens and six 5 ft. × 22 ft. tube mills. On a basis of 850 tons daily capacity, the following figures are obtained :

Cost per ton Milled.

	Stamps	Chilean Mills	Tube Mills
Labour	$0·039	$0·018	$0·014
Supplies	0·041	0·041	0·065
Power	0·054	0·047	0·087
	(232 h.p.)	(210 h.p.)	(357 h.p.)
	$0·134	$0·106	$0·166

Power consumed by stamps, Chilean mills and tube mills	22·5 h.p. hours per ton milled
Total combined cost for stamps, Chilean mills and tube mills	$0.106 per ton milled

Sizing.

Stamp Discharge	per cent.	Chilean Discharge	per cent.	Final Pulp	per c.
+ 30 ...	50·0	+ 30	4·0	+100 ..	2·6
+100 ...	23·0	+100	25·0	+150 ...	8·1
+200 ...	7·0	+200	12·0	+200 ...	9·2
200 ...	20·0	−200	19·0	−200 ..	80·1

Chilean Mills.—The use of Chilean mills following coarse or medium crushing rolls, to produce a final product where fine grinding is not required, while being far from general practice, nevertheless, is productive in some instances of most excellent results. The following data furnished by Mr. Growe of the Portland Gold Mining Company will demonstrate this.

The ore crushed is of average hardness and the mill handles 690 tons per day. Coarse crushing equipment consists of one 15 in. × 30 in. Blake crusher, one 36 in. disc crusher and one set of 18 in. × 20 in. rolls. Fine crushing is done by five 6 ft. Akron Chilean mills.

Roll Product. n.			per cent.	Chilean Mill Product.		per c
+1¾	round	aperture ...	0·7	+20	(0·0250) ...	5·5
+1½	,,	,, ...	2·9	+30	(0·0166) ...	10·5
+1	,,	,, ...	21·7	+40	(0·0125) ...	7·5
+½	,,	,, ...	36·3	+60	(0·0083) ...	10·3
+¼	square	,, ...	11·2	+100	(0·0050) ...	11·2
−¼	,,	,, ...	27·2	+200	(0·0025 ..	15·0
				−200	(0·0025) ..	10·0

The Chilean mills run at from 36 to 41 r.p.m., using from 2·5 to 3·0 tons of water per ton of ore. The Chilean steel consumption per ton of ore is 0·797 lb. gross and 0·692 lb. net. The power consumption per ton of ore in the coarse-crushing department is 1·86 h.p.-hours, and in the Chilean mills, 13·26 h.p.-hours, or a total of 15·12 h.p.-hours.

The following cost data cover the above operations :

	Coarse Crushing. per ton.	Chilean Mills. per ton.	Total. per ton.
Power (at 0·842 cents h.p. hour	$0.0199	$0.1118	$0.1317
Labour (operation) ..	0.0318	0.0179	0.0497
Labour (repairs) ..	0.0103	0.0039	0.0142
Supplies . ..	0.0284	0.0182	0.0766
Total	$0.0904	$0.1818	$0.2722

Ball Mills.—Kalgoorlie still retains the practice of dry crushing with ball mills, the two common sizes being the No. 5, 7 ft. 6 in. diam. × 3 ft. 10 in. long and the No. 8, 8 ft. 10 in. × 4 ft. 6 in., with screen areas of 70 and 100 sq. ft., speeds of 25 and 23 r.p.m., and power consumption of 25 and 60 h.p. The capacity of the No. 5 is approximately 40 tons and of the No. 8, 95 tons per day, the feed being about 2½ in. and the discharge, through 28 mesh (0·020 in.) screens, is from 40% to 50% through 200 mesh (0·0029 in.). The smaller size takes about one ton of steel balls, while the larger size takes about two tons. Steel consumption per ton milled varies from 0·4 lb. to 0·7 lb. Average total costs of ball milling are given as $0.50 per ton milled.

Wet-crushing ball mills, following rolls or cone crushers set to deliver 1 in. or 1½ in. product and supplanting stamps, are now in operation in three cyanide plants in Northern Ontario, and with most excellent results. Steel or white cast-iron balls are used and the iron consumption is stated to be from 0·5 lb. to 0·7 lb. per ton crushed, a figure which compares well with stamps crushing through the same range. A visitor to one of these plants cannot fail to be impressed by the smoothness of operation and the lack of noise, but the average mill man will look with disfavour upon the return of dry-crushing roll practice.

However, there is little doubt that this combination will soon be still further simplified by the use of large-diameter wet-crushing ball mills, using steel balls 4 in. to 5 in. in diameter and reducing a 3 in. ring feed to a point governed largely by the requirements of the subsequent treatment. Recent tests with an 8 ft. Marcy ball mill, using ⅛ in. discharge slots, demonstrate conclusively that, operated in closed circuit upon 4 in. ring maximum feed, the finished product, may be kept under 48 mesh (0·0016 in.) if desired.

These tests showed a steel consumption of approximately 0·75 lb. per ton crushed and a power consumption of approximately 12 h.p. hours per ton. Where sand leaching is to be practised, this single-stage grinding will probably prove preferable, but if the total product is to be agitated and treated as slime, then a ball-mill product passing, say, 0·25 in. aperture and final grinding in a standard tube mill would seem a more logical arrangement.

Griffin Mills.—Originally used in Kalgoorlie in competition with ball mills for dry crushing, the Griffin mill seems to have been generally superseded by the latter. The Griffin mill runs at 200 r.p.m., and with a feed of 30 tons per day of 1½ in. ore discharged through 14 mesh (0·046 in.) the final product approximates 65% through 200 mesh (0·0029 in.). The power ranges from 20 h.p. to 25 h.p. Griffin mill costs run from $0.55 to $0.70 per ton milled.

Grinding Pans. Grinding pans were probably the strongest competitors of tube mills for fine grinding, although they are now rarely installed in new plants. Kalgoorlie has 150 pans in use, following stamps, ball mills and Griffin mills. Careful classification, or elimination of finished product from the feed, is generally lacking in pan grinding, the usual practice being to feed the entire pulp from the preceding crushing machine. The following data represent averages of a number of installations of 5 ft. pans in Kalgoorlie Feed per pan per day, 23 tons of sand—54% through 150 mesh (0·0041 in.). Tons of through 150 mesh material produced per pan per day, 5·4. Power per pan, 7 h.p. at 55 r.p.m. Cost with power at 3 cents per h.p. hour, per ton of feed, $0 23 : per ton of through 150 mesh material produced, $0 65."—L. D. MILLS and M. H. KURYLA.—*Mexican Mining Journal*, May, 1916, p. 173. (H. A. W.)

ELECTRIC FURNACE DEVELOPMENT AT NIAGARA FALLS. "This paper is chiefly concerned with the economic importance of electric furnace producers depending on power from Niagara Falls. The large extent to which industry is dependent on these products and the importance of making still further use of the Falls is emphasised.

The important substances manufactured are:—

Ferro-Silicon.—For use in steel making, particularly by the basic open hearth process. Also in steel casting for the production of sound castings. Since the war none of the ferro-silicon made on the Canadian side of Niagara has been available for America.

Ferro-Chromium.—For armour plate and armour piercing projectile steels, also for automobile steels, and for the special steels required in crushing machinery.

Alloys containing Tungsten, Vanadium and Molybdenum.—Metallic aluminium is largely used in the production of the constituents of these alloys. All are used in steel making, particularly for high speed tool steels.

Ferro-Titanium.—Used in steel making. Titanium alloys are also being employed in aluminium bronze and other non-ferrous alloys.

Silicon and "75% Ferro-Silicon."—These are used in a 'new' steel, specially adapted for electrical transformer construction. Silicon is important since by its action on caustic soda, hydrogen can be cheaply produced—specially suitable where portable generating outfits are required.

Aluminium.—The largest of the electro-chemical industries in point of power consumed and value of product.

Abrasives.—Till 1914 artificial abrasives from Niagara Falls and elsewhere accounted for 62% of the United States consumption. Since the imports of naturally occurring emery from Greece and Turkey ceased, practically the whole field is supplied by the artificial abrasives, carborundum and alundum.

Calcium Carbide and Calcium Cyanamide.—The latter might be depended on to supply the necessary nitric acid and nitrates in the event of a failure of the supply of Chilian nitrate.

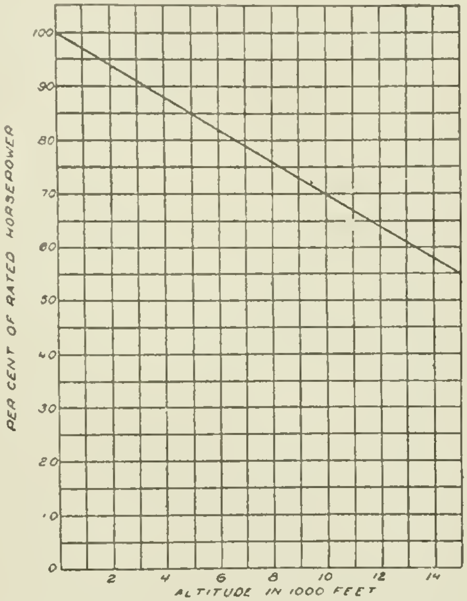
Artificial Graphite.—For electrodes and in the powdered form for the manufacture of dry cells, paints and lubricants."—F. J. Stone, paper read before American Electro-Chemical Society, 29th General Meeting.—*Mining and Engineering World*, May 13, 1916, pp. 907-909. (H. R. A.)

MISCELLANEOUS.

The Health of Old Age Colliers.—"Colliers of 55 and over have a high death rate from bronchitis. In the opinion of the author this is not due to the breathing of dust but to 'emphysema' caused by over distention of the lungs. This would be marked in earlier days when, owing to the high percentage of 'black damp' (2% to 3%) in the air of coal mines a miner during muscular exertion would breathe 10 or 12 times as much air as during rest.

Although the breathing of harmful dust may be associated with bronchitis mortality, the mortality from phthisis on this account is in far greater excess. Also coal dust cannot in this respect be considered as harmful since so far as is known it is the only dust which is eliminated from the lungs by the agency of living cells. For this reason it has even come to be regarded by medical men as a preventative of phthisis and the low death-rate from lung diseases among coal miners generally bears this out."—J. S. Haldane, M.D., F.R.S.—Paper to Institution of Mining Engineers, June 8. Printed in *The Science and Art of Mining*, June 17, 1916, p. 542. (H. R. A.)

Computing Gas Engine Horse-Power at High Altitudes.—"Gas engines and altitudes were discussed by four engineers in the *Press* of November 13, and the following note should be of further value.



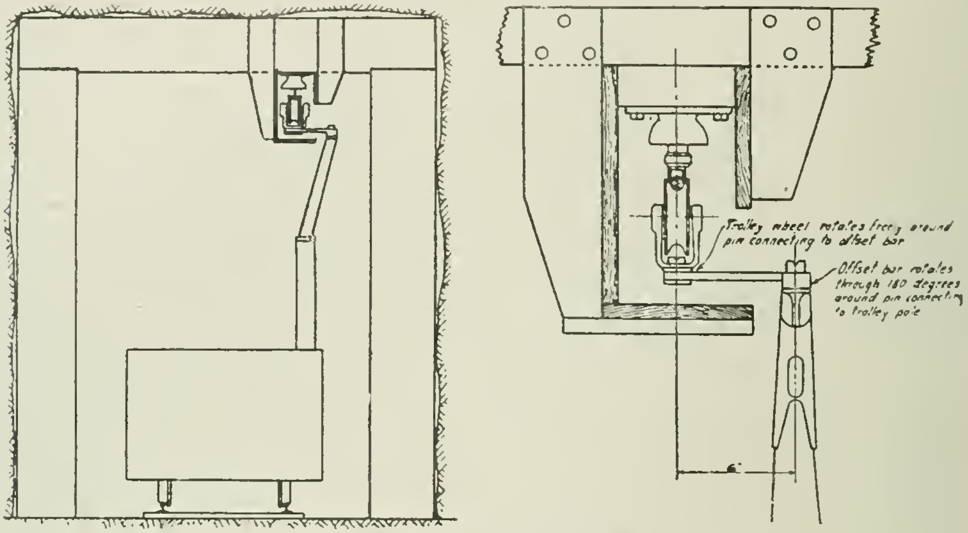
The horse-power that can be developed by an engine at a given altitude can be computed by multiplying the horse-power at sea-level by the atmospheric pressure at the given altitude and dividing by the atmospheric pressure at sea-level. Thus to compute the power developed by a 250 h.p. engine at an elevation of 8,000 ft., we have the pressure at that elevation equal to 10·9 lb. per square inch.

Then $\frac{250 \times 10{\cdot}9}{14{\cdot}7} = 185{\cdot}3$ h.p.

The calculation is simplified by the use of the accompanying chart, which is taken from *Practical Engineering*."—*Mining and Scientific Press*, March 4, 1916, p. 333. (G. H. S.)

Safety Trolley Wire Box.—"During the past few years there have been several accidents in Butte mines, caused by men accidently getting into contact with the trolley wires used in connection with the electric haulage system. Some difficulty has been encountered in providing satisfactory protection against such accidents. The guards generally used consisted of two boards placed in a vertical position, one on each side of the wire. On account of the fact that the trolley-pole and trolley-wheel were in a straight line and in a vertical position, it was impossible to protect the wire from beneath, and there was always the danger of a man carrying a drill on his shoulder touching the end of the drill against the wire.

The trolley-wire box and trolley-pole which are shown in the accompanying illustration were devised at the Steward mine for the purpose of eliminating this danger. The main features are: a trolley-pole which supports the trolley-wheel by means of a horizontal offset plate, and a horizontal board guard which prevents the wire from being touched by anything pushed toward it from beneath. The use of this board is, of course, made possible only by the use of the offset trolley-wheel.


Trolley wheel rotates freely around pin connecting to offset bar
Offset bar rotates through 180 degrees around pin connecting to trolley pole

An Underground Trolley-Wire Guard.

As will be seen in the sketch, the side opening through which the trolley-wheel is brought into contact with the trolley-wire, should be placed opposite the near side of the drift. It is then practically impossible for a man to accidentally get anything into contact with the wire.

In case the trolley-wheel should jump off the wire, the horizontal offset piece will bear against the lower edge of the side board nearest the trolley-pole, and will prevent the trolley-wheel from doing any damage. When using the old type of guard the trolley-wheel sometimes jumped off the wire and tore off the trolley-wire supports before the motorman could get control of the pole.

This guard has now been in use on the 2,800 ft. level of the Steward mine for two months and has given complete satisfaction. Any man who has been knocked down and dazed by a shock from a trolley-wire will appreciate the device here described."—*Mining and Scientific Press*, March 4, 1916. (G. H. S.)

Abstracts of Patent Applications.

(C.) 158.16. Charles Bruce Foley. Electro-thermic induction furnaces. 3.7.16.

This application refers to details in the arrangement of induction furnaces.

(C.) 160.16. Gogu Constantinesco (1), Walter Haddon (2). Improvements in and relating to fluid wave transmission. 3.7.16.

This application refers to a means in a mechanical wave transmission system whereby different fluids may be used in different parts of the system. These fluids are separated by a floating piston

This application refers to a means for regulating

which controls valves whereby leakage on either side of the system is made up by the opening or closing of valves on either side, dependent upon the mean position of the separating piston.

(C.) 161.16. Gogu Constantinesco (1), Walter Haddon (2). Improved means for compensating for leakage in wave transmission systems. 3.7.16.

or compensating for leakage of fluid in the mechanical wave system, and describes various forms of apparatus whereby a leakage in a machine which should have none, cuts off the machine, and whereby a certain amount of leakage of the fluid, if desirable, may be regulated, so that with excessive leakage the machine is automatically cut out.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Davidson, J., *l/o* Germiston; Consolidated Langlaagte Mines, P.O. Box 15, Langlaagte.

Harley, J. P., *l/o* Scotland; c/o Finlay Fleming & Co., Tavoy, Lower Burma, India.

Holloway, G. T., *l/o* London; c/o Bureau of Mines, Parliament Buildings, Toronto, Canada.

Honnold, W. L., *l/o* London; c/o The Commissioner for Relief in Belgium, 120, Broadway, New York, U.S.A.

Lundholm, G., *l/o* Modderfontein; c/o 'Carlton,' Beulah Hill, Upper Norwood, London, S.E.

Ordman, D., *l/o* Johannesburg; No. 2301, S.A.S.C., Mechanical Transport, Field Post Office, Kilindini.

Paterson, G. O., *to* P.O. Box 1, Millsite, via Randfontein.

Rusden, H., *to* P.O. Box 809, Johannesburg.

Waters, W., *l/o* England; P.O. Box 4575, Johannesburg.

LIBRARY
APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. OCTOBER 1916. No. 4

Proceedings
AT
Ordinary General Meeting,
October 21, 1916.

The Ordinary General Meeting of the Society was held in the South African School of Mines Building, Johannesburg, on Saturday, October 21st, 1916, Prof. J. A. Wilkinson (President), in the chair. There were also present:—

13 Members.—Messrs. H. A. White, H. R. Adam, John Watson, W. R. Dowling, Prof. G. H. Stanley, J. E. Thomas (Members of Council), R. W. Bennett, H. C. Hilton, S. Nettleton, E. A. Osterloh, J. J. R. Smythe, A. Thomas and T. P. Waites.

4 Associates and Students.—Messrs. R. A. Porter, D. W. Pugh, W. Waters and G. C. Wilson.

8 Visitors and Fred Rowland (Secretary).

MINUTES.

The Minutes of the last Ordinary General Meeting, held on Saturday, 16th September, 1916, were confirmed.

ELECTION OF NEW MEMBER.

Messrs. W. R. Dowling and John Watson were elected scrutineers, and, after their scrutiny of the ballot papers, the President declared the following gentleman unanimously elected to membership:

Rowe, Charles, Geldenhuis Deep, Ltd., P.O. Box 54, Cleveland. Cyanide Foreman.

ROLL OF HONOUR.

LIEUT. G. SIMPSON, JNR.

The President: It is with deep regret that I have to announce the death of one of our members, Lieutenant G. Simpson, Jnr., of the Durham Light Infantry, on the 3rd July, in Flanders.

I also beg to announce with much regret the decease of an old member, Mr. J. H. Stevens, the Secretary of the Village Main Reef, who died on the 13th of this month.

I would ask you, in honour to their memory, to pass a vote standing.

All present rose to their feet.

GENERAL BUSINESS.

SHAKING CHUTE FOR FLAT STOPES.

Mr. S. Nettleton *(Member):* The shaking conveyor brought to your notice is designed for use in mines, such as those of the East Rand, where the stopes are fairly flat.

First I would call your attention to the systems of tramming usually adopted in these mines, where the reef has a dip of 8° or 10°. The general arrangement is for the trucks to be hauled into the stope by a compressed air or electric winch placed at the top of a main track running through the middle of the stope. From this main line the trucks are taken by hand to the face on tracks, which run on strike level, *i.e.*, at right angles to the stope face, or

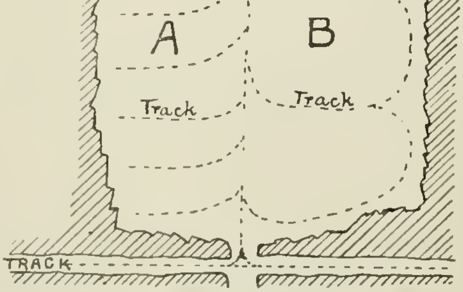


Fig. I.—Systems of track laying for loading of trucks at stope face.

on loop lines, by which loaded trucks return to the main track at the junction immediately below that, at which they enter as empties. The two systems are shown in portions A and B of Fig. II., and both possess serious disadvantages as regards the amount of labour necessary for delivery of the ore at the underlying level. Where the stope tracks run at right angles to the face one set of natives load on two adjoining tracks, moving from one point to another as each run of full trucks is replaced by empties. Owing to the position of the rock to be handled, only two or three trucks can be loaded at a time on one track, and to avoid the rock being shovelled several times before it reaches the truck, the tracks must be laid fairly close together. This necessitates a considerable amount of tracklaying and a large number of switches on the main line.

The second system of tracklaying, as shown in portion B of Fig. I., allows the trucks to take a course parallel to the stope face, and run largely by gravity from leaving, to their return to the winch line. The chief objection to this arrangement is possible breakage of the circuit by blasting operations. To avoid the shovelling of ore several times the tracks should be laid as close as possible to the stope face. They may be protected to some extent by a covering of loose rock previous to the daily blast, but the laying down and the removal of material at the end and commencement of each shift seriously curtails the time available for actual loading of rock. Frequently defects in the track, such as bent or broken rails are not discovered until trucks run over them, and much time may be wasted by the "lashing boys," whilst the tracks are being put into workable condition. When all the rock from a stope is dealt with by one main winch line, the proportion of boys actually engaged on shovelling is small relative to the total number employed in the stope. In addition to the natives employed in pushing trucks between the main track and the face and shunting trucks with the rope, it is necessary to have two boys on the winch. When there is slack rope on the drum, the driver cannot always deal with the recoiling, and the rope is liable to become entangled in the gearing of the winch.

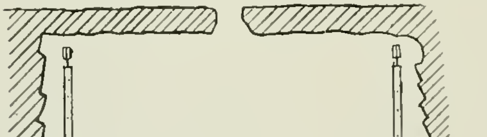


Fig. II.—Arrangement for loading trucks on level by means of conveyors and chutes.

The conditions existing in some East Rand mines suggest, that some form of face conveyor, such as those employed in European Collieries, might be adopted with advantage. At an English colliery I have seen trucks, each of 40 cub. ft. capacity, loaded from one working face at an average rate of a truck per minute on a two hours' run, but for reasons which it is scarcely necessary to bring before you, most of the conveyors applicable to coal mining conditions are unsuitable for use in mines, where heavy blasting is necessary for breaking out the mineral.

The most simple method of getting material out of a stope is by a gravity chute. When the ore cannot be moved by gravitation, shaker chutes or a series of troughs swung from chains are frequently employed, but these cease to be efficient, when fixed at inclinations of less than 8° or 10° from the horizontal.

If an ordinary trough conveyor carried by chains in a horizontal position is subjected to a simple reciprocating motion, material placed in it has no tendency to travel—it simply moves backwards and forwards for short distances, according to the length and velocity of the stroke. Relative motion between the trough and its contents takes place, when there is a rapid change in velocity or direction of the trough. The ordinary shaking conveyor has a maximum velocity at the middle of the stroke, hence to be of value it requires the force of gravity to assist in the movement of its contents. By altering the point of maximum velocity from the centre of the stroke material placed in a scavenging trough has a tendency to slip more in one direction than the other. In Fig. III. are shown curves representative of the velocities at different periods of the stroke of two conveyors. The continuous line shows the curve of motion derived from a simple crank, as illustrated, ordinates showing the distance moved and abscissae denoting time or fractions of a revolution of the crank. The dotted line shows a curve of motion, which will propel material along a horizontal trough. It will be noticed that the point of maximum velocity is approached at the end of the stroke. The movement commences very slowly, and the speed rapidly increases as the trough advances. The return stroke is practically the reverse of the advance, having a decreasing velocity throughout.

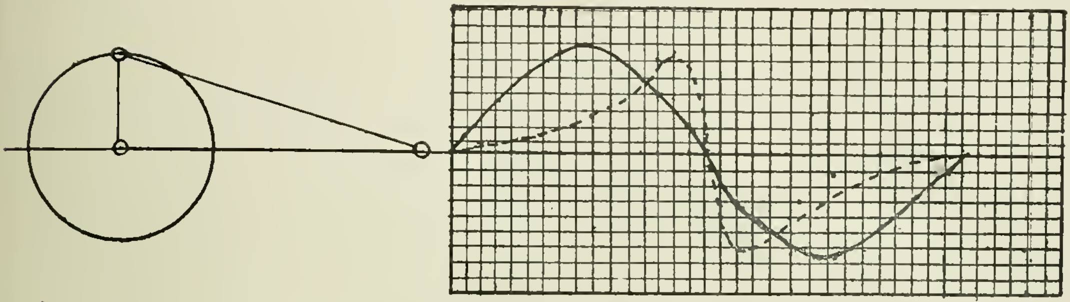


Fig. III.——— *Represents motion produced by simple crank as shown.*
- - - - *Represents motion produced by Nettleton's Patent Driving Gear.*

The motion of the model shown is not quite the same as that given in Fig. III. Dividing a revolution of the driving gear into fractions, which represent periods of time, each eighth of one revolution produces a movement on the conveyor in the following proportions:—

Advancing, 1, 9, 23 and 7
Returning, 10, 20, 9 and 1

In other words, the movement in a total stroke of 20 in. would be:—

First quarter of a revolution, 5 in. forward.
Second quarter of a revolution, 15 in. forward.
Third quarter of a revolution, 15 in. returned.
Fourth quarter of a revolution, 5 in. return.

Theoretically, these may not be the best proportions for production of greatest efficiency, but as in most engineering problems, some compromise is necessary for the attainment of practical working conditions. To move the point of maximum velocity nearer the end of the stroke would result in heavy shocks on the driving gear, increased consumption of power and excessive wear on the mechanism.

The gearing for the production of the motion described, as may be seen from the model, is intended to be fixed on a bar, such as that used for support of an ordinary rock drilling machine, the necessary power being derived from a small electric motor or compressed air engine.

By the use of a stope face conveyor natives engaged in shovelling are well under supervision. The time spent in fixing and dismantling the conveyor at the commencement and termination of each shift, should be less than the time usually spent in clearing tracks of broken rock under usual conditions of tramming. No winch and rope boys are necessary, and, as the conveyor delivers the ore into a box at the bottom of the stope, a temporary stoppage in the supply of empty trucks does not interfere with shovelling operations at the face.

Tracks from the benches to the centre of a stope necessitate a considerable expenditure in roof support, for maintenance of height for passage of trucks and general safety.

Much attention is given to roof support and, in my opinion, it is desirable, that even more should be given to roof control. Let the roof fall in the worked out areas and get rid of the large open spaces underground. Relieve the weight on the face and mineral, as a rule, is more easily worked. Natives, in going from stope face to main tracks, are apt to take short cuts, which may have disastrous results. As you are aware, the death-rate from falls of hanging is greater than from any other source of mortality on the mines of the Rand.

By adopting a system of conveyors, which permits all mining operations in stopes to be confined to the working face, it seems possible to reduce the number of accidents, improve the ventilation by forcing the air where it is most required, and effect a considerable economy in removal of ore to the main levels.

The principle of the shaking conveyor, as described, could probably be applied with success to work other than the removal of ore from stopes underground. It might be utilized, say, for the transport of sand and other material in reduction works.

The President: I should like to ask Mr. Nettleton if this has yet been tried under working conditions.

Mr. S. Nettleton *(Member)*: Not yet, but I hope it will be during the next fortnight. The machinery was ordered, but, owing to strikes, or other incidents, over which we have no control, the thing has not yet been put into practical operation.

Mr. J E. Thomas *(Past-President)*: I believe in the sugar factories in Natal you find what are called Grasshopper conveyors conveying sugar up a slight incline. They are worked somewhat on the same lines as the model exhibited, but not with the same motion, which, as far as I remember, is produced by a cam. The sugar was taken up at an angle of about 3°. I should think these conveyors would be also applicable to underground working, and possibly might be a little simpler and somewhat less costly to maintain.

Mr. W. R. Dowling *(Past-President)*: I would like to know what length it is practicable to make a machine of this sort, with a view to its transporting sand?

Mr. S. Nettleton: The arrangement was designed, not for running up hill, but a slight gradient in favour of the load. I have seen ordinary conveyor machines, I think, working up to 150 ft. I would not like to say the length possible in my methods; it would very largely depend on the dip. If you got a few degrees in favour of the load, it would make a tremendous difference in the efficiency of these conveyors. The model will lift stuff forward up to 8°. The idea was to fix the gear on an ordinary jack-bar, such as is used for ordinary machines, the jack-bar being fixed in the stope.

The President: Can you give any idea how would it compare in first cost and maintenance with the machines, which are now being used for transporting on the surface sand and things of that sort?

Mr. S. Nettleton: I have no idea of the cost of the machines in use for transporting sands, but the gear for my machine, apart from the motor, or the air engine, costs about £60. The cost of the winch, such as is used ordinarily for the top of a stope, is about £150. Against the cost of the shaker chute and chains is the cost of the rails, the ropes and the general maintenance. Personally, I think it would cost less to run this gear on compressed air than a stope winch, because there is not the hauling of the empty trucks up the stope and the dragging out of the full trucks at the junctions. Further, it has continuous running, against that of a winch which runs intermittently, and which is often used for lifting the trucks on to the lines at the points. The boys run the trucks too quickly, and they get off the track, and they use the winch as the handiest means of getting them on to the track again.

The President: If there is no further discussion on this, I should like to offer a very hearty vote of thanks to Mr. Nettleton for having brought this forward, along with the model, which makes his idea so very clear and manifest.

INVITATIONS TO MEMBERS.

The Secretary: The Council of the Institution of Engineers has extended a cordial invitation to the members of this Society to attend their next meeting, on the 11th November, and to contribute to the discussion on a paper by Mr. S. B. Bilbrough on "The Prospects of the Carbonisation of Coal, with By-product Recovery, as a South African Industry,"

Mr. G. Hildick Smith has also asked me to say, that he will be glad to see any members, who care to visit the work which has been done at the Bantjes Mine, in connection with the collapse and recovery of the Central Incline Shaft on any Saturday morning. If members wishing to see the works will let him know, an inspection could be arranged any time between 9.30 and 11.30 a.m.

The President: I am informed, on very high authority, that the invitation which has been given to you, is well worth accepting. I am not a mining man myself, but my mining friends tell me the work that has been done at the Bantjes is quite unique, so far as the Rand is concerned, and it should appeal especially to our mining members. I hope, therefore, that some of them will take the opportunity thus presented.

THE HARDENING AND ANNEALING OF METALS.

By Thomas Turner, M.Sc., Professor,
University of Birmingham.
(Hon. Member.)

It has been known from the earliest days of metallurgy that virgin metals, such as gold, silver and copper are too soft for many useful purposes, and that they can be hardened by certain processes. Doubtless, in the first instance, such processes were accidently discovered. The workmen of ancient Egypt, and of other countries on the Mediterranean seaboard, for example, used tools of hardened copper or brass before the introduction of iron and steel. In recent years claims have been made that the "lost art" of hardening copper has been rediscovered and materials have been placed on the market which were stated to have remarkable properties. Such claims have been unsupported by scientific evidence, and any samples which I have had an opportunity of examining were distinctly softer than steel, and were of no practical value for the production of cutting tools. There is, in fact, no lost art of hardening copper, brass, or bronze.

The methods which were employed by the ancients, and which are still in use in the present day, for the hardening of copper may be classed under three heads:—

1. Cold working—such as hammering, drawing, etc.
2. Alloying with other metals, such as tin. In early times iron or arsenic was used, and they are still sometimes employed.
3. Heat treatment—such as heating to a given temperature, and quenching in a liquid of special composition. The secret constituents usually appear to include urine, or sal ammoniac, or both. In a similar way there are three methods of hardening iron and steel.

1. Cold working;
2. Alloying with another element; and
3. Quenching.

The present paper is concerned chiefly with the first of these three methods of hardening.

The influence exerted by cold working upon the properties of many metals and alloys is profound. The tensile strength is increased, and is not unusually at least doubled: the elastic limit is raised; while the ductility, as measured by the elongation and reduction of area, is very markedly diminished. Thus a piece of soft copper can be readily twisted or bent; and if struck with a hammer it emits a dull sound. The same metal after cold working is elastic, and resists all attempts at permanent deformation, even preferring to break than to bend. When struck with a hammer it can be made to emit a clear note. When the hard copper is annealed by being heated for a short time to a suitable temperature, it becomes soft and ductile as before. Thus the differences in mechanical properties between hard and soft copper, of exactly the same chemical composition, are greater than those which exist between some metals which are recognised by the chemist as being separate elements.

In considering the nature of the additional hardness which results from cold working, it should be remembered that hardness may be exhibited in different ways. A metal which makes a good cutting tool, does not necessarily resist abrasion well. Nor does a metal with high tenacity always keep a good cutting edge. If a ductile metal be hardened by the addition of another element, which passes into solid solution, it will usually be found that the hardness is increased, no matter by what method this hardness is measured. Different methods of measuring hardness will in this case also yield results which are in more or less general correspondence. But when a ductile metal is hardened by cold working its hardness as measured by the sclerometer (or scratching) test is but very little greater than in the soft state. The Brinell (or ball hardness) test, and the scleroscope (or rebounding weight) test, on the other hand, give increases which are closely in agreement with the tensile strength. The hardness due to cold working, therefore, differs in kind from that which results from the inherent properties of the normal material, whether that material be a pure metal or an alloy.

It is found with the common or ductile metals, when they are examined in the cast or un-worked condition, that their hardness decreases as the atomic volume increases. In other words, the more closely the units of mass are packed together the harder the material becomes. It might, therefore, perhaps, be assumed that the hardness of worked metals is due to increased density as a result of the pressure which has been exerted. As a matter of fact metals are practically incompressible. Within the elastic limit a sample, if subjected to stress, returns to its original size and shape when the stress is removed. Within this range of stress no strain, or permanent deformation, occurs and no increase of hardness is observed. When the elastic limit of a ductile metal is exceeded the metal begins to flow; "plastic deformation" occurs, and worked hardness results. A change of density now occurs, though it is so small that for ordinary purposes it is negligible. The first result is usually a slight increase of density due to the closing up of the small blow holes, and other pores in the material. But when permanent distortion commences it is accompanied by a slight, but quite measurable, diminution of density. This is what might be anticipated in the case of drawing into wire, where the material is evidently in a state of tension. Thus Brunton has shown that in drawing steel wire it is possible to increase the specific gravity from 7·768 to 7·908 by cold work, but that when this point is reached further drawing causes the density to decrease.* Mr. Longmuir also quotes Kahlbaum as having shown in 1904 that the density of platinum is reduced from 21·43 to 21·41 by wire drawing.† Experiments have also been conducted by Lowry & Parker on the "Density of Metallic Filings" (Journal of the Chemical Society, 1915, Vol. 107, page 1005) from which it appears that the particles of metal torn off in the act of filing are in a worked-hard condition, and that on complete annealing their density increases. These particular experiments are of great interest as indicating at present unexplained stages in the annealing process. Further, recent experiments conducted by Prof. Lea, of the University of Birmingham, have shown that even under a compressive stress, which leads to distortion, mild steel has its density appreciably diminished. Tests which I have made with blanks for nuts, which are pressed out of a plate of mild steel, also show that there is no increase of density due to compression, but rather a slight diminution due to the shearing strain. It appears, therefore, that any kind of stress which produces permanent distortion, whether such stress be applied in the form of a blow, a push, or a pull, ultimately results in diminution rather than increase of density. We are thus again led to the conclusion that the hardness accruing from cold working is a result of some forces which are quite different from those which are inherent in the mass of the normal or unwrought metal. We are further led to the suggestion that the interior of worked hard metal that is caused to flow is in a state of internal tension. In other words it is being stretched; this is the case even when the stresses have been applied in a manner which may be regarded as compressive.

In order to obtain a mental image of the internal condition of a piece of hard, cold worked metal it is necessary to picture two series of forces, each of which tends to increase the hardness and tensile strength of the material. The first of these is the normal attraction exercised by adjacent molecules upon each other, or what we usually call adhesion. This inherent attraction is dependent upon the nature of the material itself, and in similar materials it is closely connected with the atomic volume.* Secondly, there is the added tenacity, resulting from cold working: this tension varies with the amount of work which has been done, and the temperature at which it has been conducted. It is not uniform throughout the mass of the material. Thus in the 1914 May Lecture of the Institute of Metals, Prof. Heyn discussed the Internal Strain in cold wrought metals, and showed experimentally that in a cold drawn bar the outside was in tension, while the inside, or unaltered portion, was in compression. We may then consider separately the original structure of the metal, and the effect produced upon this structure by cold working.

---

* *Journal of the Iron and Steel Institute*, 1906, vol. II., page 153.

† *Journal of the Iron and Steel Institute*, 1913, vol. I., page 93.

*For information on this aspect of the subject, the paper contributed by Dr. Desch on "The Hardness of Solid Solutions" may be read with advantage. (Faraday Society, Nov. 1914).

It is well known that any cast metal, when examined under the microscope, with suitable magnification, exhibits a structure which may be termed polygonal when viewed in one plane, or cellular or granular, if regarded as a whole. The ideal structure would be regular like a honeycomb, with hexagonal sections. The difference between these cells or grains and a honeycomb appears to be that while the latter grows from outside, the former begin their growth from within. In practice metallic crystal grains or aggregates, grow at different rates, and hence are of irregular size and shape; but for simplicity we may regard them as being hexagonal. Each hexagon may be considered to be a section of a metallic grain made up of a very large number of separate constituent crystals. These crystals are usually cubic, and their lines of growth, in adjacent crystal grains, are not parallel; in other words, the separate crystal grains, though made up of similar crystals, are differently oriented. Between the crystal grains there is a boundary consisting of the last remaining mother liquor, which solidified after all the ordinary crystals had formed. With pure metals this boundary envelope is very thin; with less pure material it may assume relatively large dimensions. Upon the character of this dividing envelope the mechanical properties of the metal very largely depend. If the envelope is brittle and weak, then the application of mechanical force will cause the cementing material to break, and the grains will readily separate from each other. In such cases the metal is brittle; it cannot be cold rolled, stretched, or drawn into wire. But if the envelope is as strong as, or stronger than, the body of the metallic grain, then the metal is generally ductile; and fracture, if it occurs, takes place preferentially through the grain instead of through the material of the envelope.

When we are cold working metals, however, we are not concerned with stresses sufficient to cause fracture, but with smaller forces which cause plastic deformation; and it is important to understand how such deformation may occur. The researches of Ewing and Rosenhain have shown that, on the smooth surface of a piece of metal which has been deformed by bending, there are a number of parallel lines which can be plainly seen under the microscope. These lines mark off a crystal area, as above described, into a number of bands; and as there is evidence that sliding, slip, or shear occurred on planes which are indicated by this parallel marking, these lines are called "slip bands." It might, perhaps, be anticipated that slip would occur along planes at right angles to the direction of the bend, but this is by no means uniformly the case. When the slip bands which traverse adjacent crystal grains are examined it will be found that the series of parallel lines in adjacent areas are not parallel with each other. It is therefore that the planes along which slip has taken place are determined by the original arrangement of the crystals elements in the crystal area, and by the planes of symmetry in those constituent crystals. It is easy to see that in a cube there are very many planes upon which slip might occur; these include not only all planes which are parallel to the original faces of the cube, or in other words at right angles to one of the axes; but also, and preferably all those which are parallel to any of the eight faces of the regular octahedron which is derived from the cube. On the other hand there are also many directions along which slip is not possible so long as the metal adheres to its crystalline habit. This aspect of the question, as applied to steel has been elaborated by McCance, in his paper "A Contribution to the Theory of Hardening." *Journal of the Iron and Steel Institute*, 1914, Vol. I, p. 233).

In the consideration of what happens, during this slipping of one surface of the crystal grain over another, we may perhaps get some assistance from geology. Where a fault occurs, and slip has taken place, it is not unusual to find smooth and polished surfaces, known as slickensides. These smooth surfaces result from the crushing and rubbing action whereby the structure of the original rock is obliterated, while a hard, polished, and relatively amorphous layer is produced on the surfaces which have been in contact.

The extremely interesting researches of Dr. Beilby, which are summarised in the second May Lecture of the Institute of Metals (1911), have shown that when a surface of even a brittle metal is polished a similar result is obtained. The particles of the metal, under the action of a burnisher, or even during the process of buffing, are spread out so as to fill up any hollows, and to make the rough places plain. The surface layer so obtained is harder than the original metal: and it has so lost its crystalline character, when examined under the microscope, as to be called "Amorphous."[*] Some discussion has taken place upon the classification of metals under two heads, namely (a). the crystalline, unworked, or soft condition: and (b) the amorphous, cold worked, or hard state. As to the broad distinction which exists there can be no question, and the only point in dispute is as to whether a crystallized metal ever becomes really amorphous.[†] The suggestion is made that what appears to be amorphous is in fact made up of crystals of ultra-microscopic size. It is, however, convenient to adhere, for the present at all events, to the word amorphous as employed by Dr. Beilby. If considered necessary a mental reservation may be made when the term is employed.

We have thus seen that when a ductile metal is bent, or otherwise strained beyond its elastic limit, slip has occurred along certain planes which are determined by the structure of the constituent crystals. At these planes there will be thin layers or films of metal which have been stretched to the breaking point, and which are presumably still in a state of tension. The properties of such thin stretched films are, therefore, deserving of some study. A plastic metal flows under pressure much as a liquid does: hence the properties of liquid films are interesting in the present enquiry.

If a fly walking on water be carefully observed it will be noted that it is supported in a hollow in the surface of the liquid. There is, in fact, a skin upon the surface of even perfectly pure water which is stronger than the liquid underneath, and the surface acts like a stretched membrane. This may be explained by assuming that all particles in the body of the liquid are attracting their neighbours in all directions. The particles at the surface, however, have no neighbours above them, so they attract each other with extra force. This force is known as surface tension. A familiar example of surface tension is seen in the soap bubble. A drop of water cannot support itself: but if it be blown into a bubble it is capable not merely of supporting itself, but of also supporting an additional drop of considerable size.

A liquid like water has no appreciable tenacity as measured in the usual manner: but it has quite an appreciable surface tension. If now, we imagine a quantity of water to be made up of a succession of surface layers, superimposed one upon another, but just not touching each other, we should have a material of very appreciable tenacity. It is only a step further to suppose that a cold worked metal is made up of an indefinitely large number of surface films which are separated from each other by the residues of the original crystalline material. The capillarity constant of certain solid metals, or in other words, the pull exerted upon one millimetre of surface, was calculated by Quincke.[*] With iron, silver, and gold the ratios of the hard to the annealed state was as about 3 or 4 to 1. With certain alloys the ratio was less than 2 to 1 With steel it was about 7 to 1. In any case it is only a small multiple of the tenacity of the original material. When it is remembered that the whole of the crystalline material can never be converted into thin films; and further, that these films are not all in one direction, it follows that the result of work cannot indefinitely increase the strength of a metal. The fact that in practice the tenacity is not often more than doubled is in accordance with the views expressed above.

Gold leaf affords what is probably the best opportunity of showing the behaviour of a thin film of a ductile metal. The process of manufacture may be considered to commence with the production of a thin sheet of rolled metal, which is uniform in appearance and opaque. This is now placed between sheets of prepared skin, and beaten in successive stages to the required thinness. If the sheet be placed upon a plate of glass at intervals during the gold beating process it will be observed that it is no longer uniform, but that it is broken up in many places, so that light can readily pass. But ultimately these cracks and spaces disappear, and a sheet is obtained which, apart from accidental defects, is uniform, and which transmits a green light. This result is obtained with metal of about 3 or 4 millionths of an inch in thickness. If such a sheet be suspended freely in the air and heated to a moderate temperature it will be observed that the first effect of heating is to produce a distinct shrinkage in the area of the sheet. In other words, it becomes both shorter and narrower. From this it appears to be evident that though the forces which acted to cause the flow of the metal acted compressively, the material, in process of flowing, had set up internal tensile stresses. The application of heat permits the resulting strains to be removed, and the metal to readjust itself. Microscopically it now begins to show a certain amount of definite structure which was absent from the original sheet. If a sheet of gold leaf be laid upon glass, and heated to a higher temperature, or rather over 500° C., it will undergo a further remarkable change. The particles will bunch themselves together, and light will pass freely through the intervening network, so that what is called transparent gold will result. This change probably corresponds with the recrystallization of the metal.

---

[*] See W. Rosenhain, "Deformation and Fracture in Iron and Steel." *Journal of the Iron and Steel Institute*, 1906, vol. II., pages 202-206. Also Carpenter & Edwards, "The Hardening of Metals," ibid 1914, vol. I., p. 138.

[†] Compare M Cance ibid, page 231.

[*] *Phil. Mag.*, 1868, vol. 36, 4th Series, p 267.

Summarizing what has been advanced, it may be said that there is reason to believe that when a crystalline metal or alloy is deformed by pressure the change of shape which occurs results from slip (or shear) along internal planes the position and direction of which are determined by the crystal symmetry. During the process of shearing the parts of the metal which are adjacent to the plane of slip are stretched beyond their elastic limit, and ultimately to the breaking point. This stretching, and the rubbing action which accompanies it, leads to the formation of a film of "Amorphous" material which possesses properties which are closely allied to those of a surface film in a liquid, one of the most notable properties being the increased tenacity (or surface tension) which is observed. The first effect of annealing is to release the state of strain which exists in these thin films, and thus to lead to a slight increase in the density of the metal. The subsequent result of annealing is to permit of recrystallization, and with the progressive increase of crystal size, as the temperature of annealing is increased, the resulting annealed metal becomes weaker and weaker in its resistance to tensile or compressive forces. Probably, for many purposes, the proper annealing temperature is that which will just release the strain which exists in the surface films, without at the same time increasing the crystal size. In other cases, as where the metal is annealed merely to facilitate further mechanical work, special softness may be desired, and a higher annealing temperature would be employed with advantage.

It may be added that for any who may be interested in this subject, and who may desire to pursue it further, the Bibliography given by S. W. Smith in his paper on the "Surface Tension of Molten Metals" will be found most useful. (*Journal of the Institute of Metals*, Vol. XII., 1914, p. 208). To that list may be added a paper by B. Bergman of Stockholm, "*Über eine Methode zur Bestimmung der Oberflächenspannung amorpher Körper*," and a later paper by F. C. Thompson on "*Surface Tension Effects in the Intercrystalline Cement in Metals and the Elastic Limit.*" (*Journal of the Iron and Steel Institute*, May, 1916). In the discussion upon the last mentioned paper the author ventured to point out that care should be taken to distinguish between the surface tension effects due to the production of slip planes, and corresponding thin films in tension on the one hand; and the increased strength which might be met with in intercrystalline boundaries owing to the presence of solid solutions. As has been previously indicated the hardness in these two cases is of a different nature, and arises from a different cause.

Mr. H. A. White (*Vice-President*): I think the Society is to be congratulated on receiving this very interesting paper from Prof. Turner, dealing with a subject which is of great importance to the Rand, as also to all engineering and metallurgical districts throughout the world. I have noticed lately in the papers that a new steel alloy has been brought into use in Sheffield for tools, which seems to require no heat treatment whatsoever; just a little grinding now and then. I suppose something of the sort will be introduced on the Rand in time for our rock drills, and perhaps for shoes and dies, and things of that sort. There is no doubt about it that the treatment, which is necessary to produce the best results with drill steel underground at present, though it has been the subject of much investigation in this country, cannot be said to be definitely settled yet. I think a good many of us will remember that some of the experiments by Dr. Beilby referred to in this paper were shown when he visited us as head of one section of the British Association for the Advancement of Science. I think we were all very interested in them, especially in those which were dependent upon metals with which we were familiar here, such as gold.

Prof. G. H. Stanley *(Past-President)*: I beg to second this vote of thanks to Prof. Turner, to whom we are very much indebted for sending this paper. He has made this subject of the hardness of metals his own for years, and I think I remember a former paper of his about 15 years ago. Of course, in the meantime, the knowledge of what causes hardening has been very much advanced, and this paper, it seems to me, rather centres round Dr. Beilby's explanation. There is certainly a good deal of evidence in support of that. However, one of the difficulties in dealing with the subject is the difficulty, in the first place of defining exactly what is meant by hardness. Prof. Turner points out, in the first place, what we understand by hardness in one case, and what produces that hardness; but for a different purpose, the idea of hardness is different: the hardness is of a different kind. Mr. White has mentioned, for instance, the question of rock drills; but it does not follow at all that a material which is suitable for a machine tool will be of use for a rock drill; it might be too brittle, although its hardness is extreme. Therefore, we have two or three methods of measuring hardness, and, in recent years, especially, the Shore Scleroscope, particularly for workshop purposes, has given the best results. The Brinell machine, from the scientific point of view, gives the best results, but is perhaps too cumbersome for ordinary engineering use, and is certainly difficult to use on all parts of machinery which are now case-hardened, and for different purposes have to be hardened to different degrees. The Shore Scleroscope is being used all over the world now in workshops, in making sure that the right degree of hardness required is present. Briefly, it consists of a graduated glass tube, inside which a steel ball is dropped on to the metal under examination, so that the position to which the ball rebounds can be read off on the tube, and give the measure straight away. The only thing to be careful about is to see that it is nearly vertical to the surface. The apparatus is so simple that, although it is supplied in very complete form by scientific instrument makers, a simple form can be made by any mechanic; in fact, one was made in our engineering department of the School of Mines. It gives the same results practically as stated in the lists supplied by the scientific instrument makers.

The President: I should like to make a remark on what Prof. Stanley has said. Instruments for determining the hardness of metals have, as far as my limited knowledge goes, been brought forward within the past 10 years, and I think it would be extremely useful to the members of this Society if Prof. Stanley could bring forward a paper and demonstration on this subject, so as to bring us a little more up-to-date than we are at the present moment.

Prof. G. H. Stanley: I do not know whether I could read a paper on these things in the near future. At any rate, I think I can promise to show this scleroscope at the next meeting.

The President: I should like to endorse the remarks which have fallen from the proposer and seconder of this motion regarding the paper which you have just heard. Prof. Turner is one of our hon. members, and has been so for some years now. It is indeed a very rare event to get a paper from our hon. members overseas, and therefore our thanks are commensurate with Prof. Turner's kindness in sending this paper.

The vote was carried with acclamation.

TESTING THE STRENGTHS OF EXPLOSIVES.

By J. A. Campbell (Member).

INTRODUCTION.

The strength and other properties of explosives are frequently referred to, but the user is not always aware how much faith can be placed in the figures quoted. Sometimes two sets of figures are available, obtained by two different methods, and the user is in the dark as to which set to believe. It is with the object of explaining the apparatus used in the testing of such material (apart from its analysis) that these notes were compiled, as the results of an examination of any explosive will naturally mean more to the user if he knows how these results were obtained, and understands the limitations of the method.

Types of Apparatus.—Three types are in use for testing the strength of explosives, namely:—

(1). Bichel's Pressure Gauge.
(2). Trauzl Blocks.
(3). Ballistic Mortar.

(1). *Bichel's Pressure Gauge.* — This method is not in general use, owing to the expensive and delicate apparatus necessary, and to the time consumed in making tests. As the results are often variable, and as a series of tests with different cooling surfaces is necessary, a large number of shots is required for each explosive tested. An investigation carried out by Dr. Comey shows that the averages obtained by this method agree with the figures given by the ballistic mortar, the latter being a much more convenient apparatus to handle.

(2). *Trauzl Blocks.*—This method is still used, especially on the Continent of Europe. The lead blocks or cylinders required for this method must be cast of pure metal, and precautions taken to ensure that the lead used for each batch of cylinders is homogeneous. The standard measurements of these lead cylinders are 20 cm. high, and 20 cm. diameter, with a hole in the exact centre measuring 12·5 cm. deep by 2 cm. diameter. While Bichel's pressure gauge (1), and the ballistic mortar (3), show only the strength of an explosive, the Trauzl blocks are affected by the rate of detonation and by the temperature of the explosion. These facts limit the use of lead blocks to the comparison of explosives of the same kind. Thus it has been found that explosives containing notable amounts of aluminium, which have high temperatures of explosion, give abnormally high results in the lead blocks, probably owing to erosion of the lead by the hot gases. Slow explosives give low results, as the tamping is displaced before the full pressure can be exerted.

The maximum temperature produced by the explosion of nitroglycerine is about 3,100° C., while ammonium nitrate only gives a temperature of 1,100° C. The lead erosion evidently will be greater with a high nitroglycerine explosive like blasting gelatine than with an explosive of the ammonium nitrate class, and therefore explosives of these different types should not be compared with one another by means of lead blocks.

If due regard be paid to its limitations, the Trauzl test is certainly useful, but the different classes of explosives now in use require something more reliable.

(3). *The Ballistic mortar.*—This method is used in different forms. In one, the distance to which a shot is thrown from the mortar by the explosive is measured. In another, which permits of fairly large charges, one charged mortar on wheels is fired when close up against another empty mortar suspended from bearings, and the swing of the suspended mortar is measured. This form is adopted by the British and United States Governments.

A third variation is to fire the explosive in a mortar suspended from bearings and tamped with a heavy steel cylinder. The cylinder is thrown out, and the recoil of the mortar is a measure of the strength of the explosive. Either the weight of explosive is altered until a certain fixed deflection is produced, or a fixed amount of explosive is taken and the strength calculated from the amount of deflection. The third mentioned form of ballistic apparatus is the quickest to operate and is least liable to go out of order, and so is most in favour with the ordinary manufacturer.

In such apparatus the weights to be moved are heavy and the movements comparatively slow, therefore different explosives can be directly compared without regard to their rates of detonation. With such empirical methods as lead blocks and ballistic mortars, it is necessary to test each explosive against some standard, which may be blasting gelatine, kieselguhr dynamite, or even a low grade dynamite made up of specially selected materials.

The rate of detonation of a cartridge is one of the main factors in its efficiency, but that rate may vary with the diameter and degree of confinement, and be different at different distances from the detonator. It is at present impossible to ensure that small samples of explosives will detonate at the same comparative rate as large charges in boreholes, so it is better to test such samples by a method which is not affected by the rate of detonation, and which measures the ultimate force only.

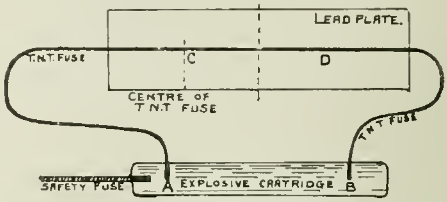
If both the strength and rate of detonation of an explosive be known, then its action in practical mining work can generally be predicted with some confidence.

Rate of Detonation.—The rate of detonation of an explosive is an extremely important property, but there is some difficulty in its determination owing to the extremely small interval of time to be measured. The question is complicated by the fact that differences in methods of manufacture, differences in the initial impulse, differences in diameters of cartridges, and differences in degrees of confinement may affect it. Again, the rate of detonation very probably is not uniform throughout the length of explosive tested. For practical purposes, the rate under the strong confinement usual in boreholes of a diameter of $\frac{7}{8}$ in. to $1\frac{1}{4}$ in. is the only useful figure, and these conditions are usually imitated by enclosing the explosive in iron tubes.

The Mettegang recorder for measuring these velocities is a refinement of the apparatus used for taking the velocity of projectiles. The breaking of primary circuit wires passing through the train of explosive induces a current in the corresponding secondary circuit, and this secondary circuit sparks across a small gap on to a rotating smoked drum driven at a known speed. A microscopic device measures the small intervals between the spark marks, and from the figures so obtained, the rate of detonation of the explosive can be calculated.

The D'Autriche method of measuring these rates of detonation is a very ingenious method, making use of comparatively simple apparatus. It employs as its standard the "instantaneous" fuse now obtainable, which consists of a thin lead tube filled with trinitrotoluol. This fuse, when detonated, has a speed of 5,500 yards per second. A length of the fuse is capped at each end with a No. 6 detonator, and these ends are inserted into the column of explosive at a measured distance apart. The fuse is tied over a strip of lead plate about 4 mm. thick, so that the middle of the fuse lies over a line drawn across the plate. The column of explosives is then detonated from the end, "A."

When the detonation takes place at "A," an explosive wave travels up the T.N.T. fuse ACDB. Meanwhile an explosive wave has also been travelling through the explosive column from "A" to "B," and eventually detonates the "B" end of the T.N.T. fuse. This detonation at "B" causes an explosive wave to travel up the T.N.T. fuse BDCA. The two waves, ACD and BD meet at, say, a point marked "D," and the force of the impact makes a distinct dent in the plate at "D." The distance from this mark "D" to the centre of the fuse "C" is then measured. The time taken by the fuse to cover this distance "D" to "C" is known, and then by calculation the time taken by the main explosion to travel through the explosive column from "A" to "B" can be determined.



D'Autriche Method of Measuring Rates of Detonation.

So far our experience has been that the figures obtained for the rate of detonation of most explosives are apt to vary considerably, and, as a matter of fact, the published results of the various experimenters show discrepancies. The rate determined for any explosive only holds good for the particular conditions of the determination. In spite of its apparently simple constitution, blasting gelatine shows wide variations under different conditions. When fired in the open, it generally detonates at a slow rate of approximately 3,000 metres per second, while under confinement it may rise to 8,000 metres. Even without confinement, blasting gelatine may show a high rate of detonation if a small primer of trinitrotoluol is inserted into the first cartridge and fired with a No. 6 detonator. This may be shown without any measuring apparatus if two lines of cartridges be fired on a thick lead plate, the one with detonator alone, and the other with detonator and trinitrotoluol primer. The difference in the craters produced in the lead is very apparent. Still, we have no evidence to prove that any addition to the ordinary No. 6 or No. 8 detonator raises the rate of detonation of blasting gelatine when confined and properly tamped in a borehole, provided that the blasting gelatine be as sensitive as it should be.

Such tests as firing explosives in the open naturally have little bearing on their behaviour under proper confinement, except that it is legitimate to infer that an explosive which gives a fast rate of detonation when unconfined will at least be no slower under working conditions.

Sensitiveness.—It is of paramount importance that an explosive be sufficiently sensitive, otherwise there is the risk of some cartridges being left unexploded. The explosive at the same time must be reasonably safe to handle.

The familiar falling weight test gives an idea of the sensitiveness of an explosive to mechanical shock, but the power of an explosive to transmit the explosive wave is equally important practically.

The test for sensitiveness is best carried out by tying two $\frac{7}{8}$ in. cartridges at varying distances apart in a thin paper cylinder, and detonating one of them. A few trials will soon determine the maximum distance apart at which the second cartridge can be completely detonated, and this distance serves as a measure of the sensitiveness of the explosive. The trial is best carried out on a rigid bar or piece of rail. Obviously, if one cartridge detonates another over a wide air gap when almost unconfined, there will be little fear of failure when the two are pressed together in close contact in a borehole.

In conclusion, it must always be borne in mind that the present methods of testing an explosive are empirical, as they measure some property of the explosive under arbitrary conditions. As these conditions vary in actual use, so also the behaviour of an explosive may be expected to vary, and consequently laboratory tests should be supplemented by large scale trials in different kinds of rock before a final verdict can be passed on the behaviour and action of any explosive.

The President: I think the saving clause in this paper is contained in the last few sentences, where the author says that, before a definite verdict is given on any explosive, it should be tested under actual working conditions. He also states that the method most in favour at the moment is the pendulum mortar, but I venture to think that the Trauzl block test has been somewhat arbitrarily put on the shelf. Some years ago I believe, that some experiments were made in Canada with an enlarged lead block, about twice as long as that used normally, and the results obtained were considered better in every way, that is, as an indication of the practical utility of the explosive tested. These blocks are difficult to make and, as far as I know, pure lead is not easy to obtain in this country in large quantities. These reasons may have possibly led to their displacement in favour of the easier and cheaper ballistic methods. With the longer lead block it is easy to see that the amount of tamping used with a given charge can be made greater and hence more closely approximate to working conditions. Perhaps the author will elucidate these points, and at the same time give us definite information concerning the experiments mentioned, to which I have referred but did not follow up.

I believe it is correct to state, that a small Trauzl block is used for testing detonators at the present time; but nothing is mentioned about that in the paper, and I think it might be useful to our members.

With these few remarks, I have very much pleasure in proposing a hearty vote of thanks to Mr. Campbell, and I hope that it will evoke much discussion, more particularly from our mining members.

Prof. G. H. Stanley: As regards obtaining pure lead as in the Trauzl block, that should present no difficulty at all, because even the ordinary pig lead will frequently run 99·9. The trouble is, I think, more in the casting of the block: there is a risk of carrying in impurities, such as oxide, mechanically.

Mr. H. R. Adam *(Member of Council).* I should like to ask Mr. Campbell if he could give us any information as to how these temperatures of explosions mentioned are measured?

The President: Mr. Campbell is not present to-night, but I feel sure he will give us this information when he comes to reply.

NOTES ON RARE MINERALS IN MADAGASCAR.

By T. P. Waites *(Member).*

(Printed in Journal, March, 1916.

REPLY TO DISCUSSION.

The President: Before calling on Mr Waites to reply, I should like to state that I have carried out some further experiments on some of his minerals, and have the results here. The betafite gives quite a good impression on the plate; rutile gives a very faint impression; it can just be seen. And bastonasite gives a slightly better impression than the rutile.

Mr. T. P. Waites *(Member):* I have a very easy task in replying to the discussion, because there has been so little. I am pleased to acknowledge the academic interest displayed by Dr. Moir in determining what these various minerals are, and by the President in exposing photographic plates to certain samples and thereby obtaining results far in advance of anything which I and others in Madagascar obtained. It is quite possible that the conditions were much better than those under which we worked, also that the plates used were much better than ours. The length of exposure which we gave these stones in Tananarive did not, in any case, extend over more than a week, whereas Prof. Wilkinson has given these plates an exposure of about a month. Personally, I consider the pictures as very remarkable. I have seen quite a considerable number of photographs of this sort, but I have seen nothing to come anywhere near the photograph which was given by the autunite: it is unique. Those of you who were here when the samples were exhibited at this table, will perhaps remember two specimens of this phosphate of uranium. The amount of phosphate of uranium which is adhering to the clay is not so thick as an ordinary coating of green paint, and yet the result is a picture showing distinctly the patches of uranium phosphate. The clay is really a mixture of decayed vegetation and ordinary clay. Perhaps the clay on which this uranium is deposited is also radio-active and uraniferous. It is also possible that the whole of this lacustrine deposit is radio-active. I do not know. We found some stones which are never mentioned in the list of radio-active minerals giving, certainly, some evidence on the photographic plates of radio-activity.

I also have to acknowledge the assistance given by the Mines Department in granting Dr. Moir authority to determine what these minerals are. To prospectors, like myself, who do not profess to be scientific in these matters, the assistance which was given by a member of the Mines Department, without money and without price, when we have shown that we have a *prima facie* case for it, is certainly very acceptable. I also have to acknowledge the interest and trouble taken by Prof. Wilkinson, the results of which, I venture to say, are better than anticipated, and more especially after drawing a complete blank in his first experiments.

May I add that I purpose obtaining about half-a-pound weight of this pure phosphate of uranium. It seems so remarkably radio-active that it is my intention to have it experimented with and see if, by continuous application to a superficial part of the body, this phosphate of uranium may have the same effect as radium, and which mesothorium has when applied for only three minutes every fortnight. If I obtain any results, I shall be pleased to communicate them to the Society.

THE MANGANESE SILVER PROBLEM

By Walter Neal *(Corresponding Member of Council).*

(Printed in Journal, September, 1916.)

Mr. F. Wartenweiler *(Member of Council):* The author is to be congratulated on his review of an exhaustive study of the El Favor manganese silver extraction problem, and thanked for bringing it before the Society. From the engrossing attention given to our daily work of gold metallurgy, it is refreshing to turn to that of silver, by no means an unimportant metal.

Referring to Mr. Neal's data, it appears that the extraction of 32 oz. silver from the 34 oz. Camuchin manganese silver ore by means of an acid brine is a favourable illustration of wet chloridization, and of the dissolution of the silver chloride formed, by the brine.

The 90% extraction with saturated salt brine and sulphur dioxide is very interesting to me, as I was engaged some years ago (1907-1908) in a metallurgical investigation on a working scale, on a silver-gold tailing and on the original ore, carrying pyrolusite in considerable quantity. The investigation included the dissolving action of sodium chloride solutions in wet chloridizing, also the chloridization of the silver ore by roasting, supplemented by wet chloridization roasting. An abstract of some of my working notes may be of interest.

The process of forming silver chloride and dissolving with basic chloride was being worked by nature in her slowly patient way, and was exemplified by the silver content (0·1 oz. per ton water) of the acid mine water issuing from the underground workings. The conditions were favourable by the presence of silver minerals, pyrolusite, chlorides, base mineral sulphides, and by mine water passing through a mineral zone of partial oxidation.

The tailing, assaying 4·2 oz. silver per ton. 0·05 oz. gold per ton. was leached with an 18% salt solution, which had been charged with electrolytically generated chlorine by passing through an absorption tower. The extraction was:

Silver	...	...	64·3%
Gold	...	...	75·0%

The precious metals were precipitated on lead shavings, giving excellent deposition provided no free chlorine remained in the effluent from the leaching vats. The solution of the silver chloride in strong salt brine is an old method, and was at one time practised under the name of the Augustin process. The precipitation reaction for the silver may be illustrated thus:

$$4AgCl + 2Pb = 2PbCl_2 + 4Ag.$$

The partially oxidized silver-gold ore, with which are associated pyrolusite, mispickel and pyrite, was roasted in a large muffle furnace with 4% salt, then leached with the salt solution (containing 18% NaCl and 0·20% free Cl_2, giving an extraction of:

Silver, 90·7% on an original value of 22·7 oz.
Gold, 75·0% on an original value of 0·10 oz.

The chloridization of the silver during the roast was 85·9% (by hypo test), and to obtain this it was necessary to subject the ore first to an oxidising roast, adding the salt in the later stage on account of the rapid evolution of SO_2 at the beginning of the roast. By keeping a low heat throughout, the volatilization loss was kept down to 5% silver and gold.

In leaching this ore with the salt solution, it is interesting to observe that an effluent carrying as high as 17 oz. silver per ton was obtained. This silver content seemed to be the saturation point as experienced in leaching high grade ore assaying 150 oz. silver per ton. Such high silver content required a long time for dissolution by the salt solution.

The same partially oxidized ore yielded to cyanide treatment after grinding through 150 mesh, as follows:—

	Silver.	Gold.
Original value ...	18·9 oz.	0·103 oz.
Extraction by cyaniding	61·5%	66·1%
Extraction by cyaniding plus concentration	75·9%	83·9%

The old and costly mill practice of chloridizing roasting with 15% salt, followed by pan amalgamation, gave an extraction of:

Silver	...	...	90%
Gold	...	...	56%

By chloridizing roasting with 6% salt, followed by cyaniding, the extraction was:

Silver	...	...	90
Gold	...	...	74%

When the ore was given an oxidizing roast only (no salt added), the solubility of the silver in cyanide solution decreased remarkably, only 18·5% being dissolved.

The meeting then terminated.

New Book.

THE SPIRIT OF THE SOIL: OR AN ACCOUNT OF NITROGEN FIXATION IN THE SOIL BY BACTERIA AND OF THE PRODUCTION OF AUXIMONES† IN BACTERIZED PEAT. By GORDON D. KNOX, with a Foreword by Prof. W. B. BOTTOMLEY (King's College). Published by Constable & Co., Ltd., London.

This octavo volume of 242 pages, divided into fifteen chapters, and illustrated with 17 photo plates, embraces a subject of much interest, at the present time, to all agricultural chemists. There are chapters on the nitrate problem, bacteria and protozoa, fixation of nitrogen by leguminous plants, humus; bacterized peat: its preparation and general properties, etc., etc. (J. W.)

Review.

ELEMENTS OF MINERALOGY. By FRANK RUTLEY; revised by H. H. READ, with an introduction by G. T. HOLLOWAY. 19th edition. London: THOS. MURBY & CO., 1916. Pp. 394. Ill., index.

"Before the present revised edition was prepared this useful little work had 18 separate printings, 13 during the author's life. Owing to the advance in the subject during recent years, and the number of appendices added to former editions, alterations in the new work were deemed necessary. Some pertinent remarks as to the association and value of minerals is given in the introduction. After a perusal of Part I., which includes the chemistry, optical and physical properties of minerals, crystallography; and Part II., describing the mineral species, we can safely recommend this as a useful and practical book, and quite up-to-date. A note is given on flotation of minerals. In a glossary of terms used in economic geology are to be found secondary enrichment, gossan, magmatic segregation, metamorphism, sedimentary rocks, tuff, and others frequently read in technical journals." —*Mining and Scientific Press*, July 1, 1916, p. 35. (G. H. S.)

---

† Auximones are said to take the place in plants which vitamines occupy with regard to animals.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Radium from Carnotite.—"The methods of extracting radium from carnotite ore as carried out in the plant at Denver have proved highly successful. They depend essentially upon the fact that strong hot nitric acid has a high co-efficient of solubility for radium and barium sulphates. The method follows in brief :

The carnotite ore, pulverized to 20-mesh, is treated in a special earthenware leaching-pot with 38% nitric acid; 500 lb. of ore being used to 121 lb. of 100% HNO_3. The acid is brought nearly to boiling by means of steam passed through a glass tube and the ore gradually stirred in. Heating is continued for fifteen minutes when the acid is filtered from the ore in a stoneware filter. This is followed by a second treatment in the same leaching-pot with somewhat weaker hot nitric acid, after which the whole is washed with hot water. Nearly all of the uranium, about 50% of the vanadium, and over 90% of the radium are carried into solution by this method and separated from the bulky residue which is then discarded. The acid solution is nearly neutralized with sodium hydroxide, barium chloride, and sulphuric acid added in proper quantities and held in settling-vats with conical bottoms for three days to settle out the radium-barium sulphate. The supernatant liquid is then siphoned into an excess of boiling sodium carbonate solution to separate the uranium and vanadium from iron, aluminium, and calcium. The radium-barium sulphate left in the vat is filtered on a stoneware filter, washed, and dried, the washings being also added to the sodium-carbonate solution already mentioned.

The soluble sodium uranyl carbonate and the sodium vanadate are filtered from the iron calcium precipitates in filter presses and run into uranium precipitation vats. The sodium carbonate is then nearly neutralized with nitric acid, and sodium hydroxide is added to complete the precipitation of the uranium as sodium uranate. The filtrate containing the vanadium is carefully neutralized with nitric acid, and iron sulphate is added to precipitate the vanadium as iron vanadate. Both the sodium uranate and the iron vanadate are separated from their solutions by means of filter presses. The filtrate from the iron vanadate consists almost wholly of a solution of sodium nitrate containing, of course, a small amount of impurity. This filtrate is evaporated, the sodium nitrate recovered and used again for the manufacture of nitric acid. The radium barium sulphate, without further treatment, is reduced in large graphite crucibles by charcoal, a very efficient conversion (90% to 95%) into barium radium sulphide being obtained. The sulphides are dissolved in hydrochloric acid and the residue of unchanged sulphates re-treated. The chloride solutions are crystallized in the plant in silica-lined kettles, care being taken to keep the solutions acid with hydrochloric acid as the separation of radium from barium is much more rapid under these conditions. The concentrated chlorides carrying from 4 mg. to 10 mg. of radium per kg. are taken to the laboratory, filtered from any insoluble impurities, and crystallized again in strong acid solution until the bulk has been reduced to a small volume, when they are converted into bromides. This is done after first neutralizing with ammonia and precipitating with hydrogen sulphide to remove the lead, which always accumulates and which is not precipitated by hydrochloric acid from strong barium chloride solution. After removal of the lead, the barium and radium are converted into carbonates by the addition of ammonium carbonate, washed, and dissolved in hydrobromic acid. From this point cystallization takes place in pure quartz dishes in solution strongly acid with hydrobromic acid.

The fractional crystallization of radium from the original chlorides to the finished product is neither tedious nor difficult, but takes place rapidly when acid solutions are used and when proper apparatus is available which will withstand their action.

A nitric acid plant has been erected which produces over 5,000 lb. of nitric acid per day. Owing to the recovery of sodium nitrate the cost of the nitric acid has been very low, averaging slightly less than 2½ cents per lb. To September 1st, 4,774 mg. of radium was produced in the form of sulphates and 1,947·5 mg. in the form of bromide. Deliveries are continuing at the rate of 300 mg. to 400 mg. per month.

The cost of radium figured on the basis of all the radium produced to August 1, which includes the higher costs of the earlier operations, was $37,500 per gram. The radium produced is being used in the Howard A. Kelly Sanatorium at Baltimore and the General Memorial Hospital, New York City, for the treatment of cancer and other malignant growths. A copy of the bulletin may be obtained by addressing the Director, Bureau of Mines, Washington, D.C."—Parsons, Moore, Lind and Schaefer, U.S. Bureau of Mines, *Bulletin* 104. *Mining and Scientific Press*, Dec. 25, 1915, p. 974. (G. H. S.)

Corrosion of Boilers.—"This is the concluding article of a series extending through the three previous issues. The author's conclusions are that distilled water free from CO_2 has the least influence on iron. Any addition of salts, especially chlorides and magnesium salts, greatly increases the formation of rust. Addition of soda to water containing CO_2 is only effective at concentrations exceeding 10%. At lower concentrations rusting is increased. Certain other salts, such as sodium hydro-sulphite, work as protective agents at a low concentration, and the reverse at high concentration. The special peculiarities of the Zurich water supply are discussed."—E. Bosshard and R. Pfenniger, *Chemiker-Zeitung*.—*Water and Water Engineering*, April 15, 1916, p. 100. (G. H. S.)

Methods for Dealing With Arsenical Sulphuric Acid in the Manufacture of Ammonium Sulphate.—"It has become necessary, recently, for many manufacturers of ammonium sulphate to use arsenical sulphuric acid, with the result that arsenic sulphide is precipitated in the saturator and the sulphate is discoloured. Three methods are available for overcoming this difficulty :—(1) The method used by shale distillers in Scotland, which consists in working with an oil film, *e.g.*, of anthracene, on the surface of the acid in the saturator. Once or twice each day the bath is diluted, heated to boiling, and then allowed to stand, whereupon the oil settles to the bottom, carrying with it tarry impurities, etc., and the precipitated arsenic sulphide, and is drawn off. (2) By using a closed saturator with an automatic scumming device: the arsenic sulphide is discharged continuously with the tarry matter, and the use of an oil film is not necessary. (3) By precipitating the arsenic from the acid by means of the waste gases from the saturator. The acid, diluted to 65% strength to avoid precipitation of sulphur, flows by gravity from a lead-lined feed vat through two closed dearsenicating vats of cast iron, preferably lined with lead, though this is not essential, as weak acid saturated with hydrogen sulphide has little or no corrosive action on cast iron. The waste gases from the saturator, after leaving the coolers, are passed through the dearsenicating vats in the opposite direction to the acid, the gas-inlet pipe in each vat terminating in a perforated horse-shoe cracker pipe of hard lead, below the level of the acid. The acid flows from the dearsenicating vats to settlers of sufficient capacity to allow of settling for 24 hours, and then passes through siphons to lead-lined filter-vats each having a false bottom of porous tiles. The concentration of the acid is reduced by 5°—6° Tw. (0·025—0·03 sp. gr. units) by the process of dearsenication. The mud in the settling vats must be washed periodically with water to recover the acid.

Attention is drawn to the great waste which occurs owing to the failure to treat coke-oven gas for the recovery of sulphur. It is estimated that at least 80% of the gas produced in coke-ovens in Great Britain is untreated so far as recovery of hydrogen sulphide is concerned and that an additional 51,600 tons of spent oxide of 50% S content might be made available from this source. It is recommended that the Ministry of Munitions should take steps to ensure recovery of this sulphur, should forbid elimination of hydrogen sulphide by means of lime, and should enforce the removal of sulphur compounds other than hydrogen sulphide by the process of Carpenter and Evans in order that the sulphur may be recovered in a useful form."—P. Parrish.—*Journal of the Society of Chemical Industry*, May 15, 1916, p. 535. (J. A. W.)

American Production of Potash.—"During 1915 potash was recovered as a by-product from the manufacture of Portland cement at Riverside, Cal.; in addition to the value of the potash, the method saves additional material to be converted into cement, and eliminates the dust nuisance. A discharge of 100 tons of dust a day over the surrounding orange groves has been prevented. Potassium sulphate from alunite was first placed on the market late in October, 1915, by a company at Marysvale, Utah. The production has not been large so far. A plant was established in the spring of 1915 at Hoffland, near Alliance, Nebraska, and during about half of the year obtained potash salts from the brine of an alkaline lake in that region. In addition to the output from these sources, potash was marketed in 1915 from kelp obtained along the Pacific coast. Operations are in progress at Searles Lake and at Keeler, on the shores of Owens Lake, Cal. One company is erecting a plant near Great Salt Lake, and another will soon be started at the south end of the lake. The by-product, bittern, at solar-evaporation plants on San Francisco Bay, has also received some attention. A small quantity of potash salts was probably produced from various silicate rocks and minerals during 1915, and found its way into mixed fertilizers without intermediate refinement. The value of the potash salts produced in the United States in 1915 is estimated at $342,000."—*Journal of the Society of Chemical Industry*, May 31, p. 600. (J. A. W.)

Indicators for the Determination of Temporary Hardness in Water.—"Comparative experiments with methyl red, sodium alizarinsulphonate, methyl orange, lacmoid, phenacetolin, and 'butter-yellow' (dimethylaminoazobenzene) on waters of known composition showed that the bicarbonate alkalinity (temporary hardness) is best determined by titration in presence of the last-named indicator. The titration is performed so that the colour matches that of a standard (containing the same amount of indicator) which is prepared by adding 0·1 cc. of an alcoholic solution of 'butter-yellow' (2:1000) and 0·40 cc. of $N/50$ sulphuric acid to 100 cc. of distilled water. Lacmoid gave the best results in the presence of alum, but low values in determining bicarbonates; its use is not recommended where the alkalinity exceeds 100 parts per million."—J. F. Norton and H. I. Knowles.—*Journal of the Society of Chemical Industry*, May 31, 1916, p. 614. (J. A. W.)

METALLURGY.

Thermal Conductivity of Refractories.—"This paper deals with 'the methods and results of an investigation designed to develop a practical and reasonably accurate means of determining the thermal conductivity of regular kinds of brick, under conditions approaching those of practice and without the necessity of preparing special shapes or samples of the materials being tested.' The author first gives a classification and review of the various methods which have been devised to measure the heat conductivity of refractories and then describes his own method.

This method of determining thermal conductivities consists of using the brick under test in the construction of one single wall of a specially constructed coke-fired furnace, and measuring the rate of heat flow through a certain area of the test wall by means of a water jacket applied to the cold side. Temperature measurements are made at various points in the brick, and from the data thus secured the conductivity of the material constituting the wall is calculated. The advantages of the method are these: Special shapes or test pieces of the refractory are not needed, the tests being made on samples of commercial brick. The conductivity is readily calculated from the observed data without recourse to complicated factors involving the shape of the conducting body. Variation of the conductivity with temperature is made apparent by graphic representation of the temperature gradient through the brick.

The furnace consists of three permanent walls, one side and two ends, provided with a permanent roof and stack connection. These three walls are constructed of fire brick and tile, and are each 9 inches thick. The roof of the furnace and stack connection are supported from the end walls on iron bars placed as shown. The fourth wall (the front side of the furnace) is independent of the other parts of the furnace and is built of the brick to be tested. The fuel used is sized by-product coke, which is charged through the fire door at the top of the back side of the furnace. The grate consists of four iron bars. Air enters under the grate, and additional air is drawn through openings in the back side of the furnace. These openings may be closed or left open as is necessary; it is found that by regulating the amount of air entering the furnace at the various points it is possible to secure rapid combustion of the coke, from the top of the bed of fuel to the grate, a depth of about 26 in. In this manner a sufficiently large area of the test wall is heated to a uniform temperature to render permissible the use of a calorimeter 1 ft. square.

Concerning the details of the arrangement and especially the construction of the calorimeter with which the rate of heat flow through the wall is measured, the reader is referred to the complete paper to be published in the Transactions of the Society.

The method was applied by the author to tests of four types of refractories. The kinds of brick tested were first-quality fire clay brick, silica brick with clay bond, silica brick with lime bond and magnesite brick. All were manufactured by the Harbison-Walker Refractories Co., Pittsburgh, Pa.

Details of the composition of the different bricks are given in Table I.

Table I. Analysis of Brick.

Per Cent	Woodland	Quartzite	Star Silica	Magnesite
SiO_2 … … ..	52.93	73.91	95.85	2.50
Al_2O_3 … .	42.69	22.87	0.88	0.50
Fe_2O_3	1.98	1.48	0.79	7.00
CaO … …	0.33	0.29	1.80	2.75
MgO ..	0.38	0.31	0.14	86.50
Alkalies	1.55	1.20	0.39	
Loss on ignition		—		0.10
Apparent density	1.91	1.91	1.56	2.46

The results of the measurements of heat conductivities are given in Table II.

Table II. Heat Conductivities of Brick.

Material	Test No.	Exp. Temp. Range	Mean k Over Exp. Range	Calc. k at 100°	Calc. k at 1000°
Woodland	1	120 to 965	0.00676	0.00532	0.00816
Woodland	2	100 to 1025	0.00666	0.00438	0.00880
Woodland	3	400 to 995	0.00704	0.00332	0.00886
Quartzite	1	100 to 935	0.00679	0.00504	0.00880
Quartzite	2	100 to 960	0.00670	0.00521	0.00836
Star Silica	1	100 to 950	0.00794	0.00561	0.0108
Magnesite	1	115 to 850	0.0343	—	0.0313

The third column gives the temperature range in deg. C. for each test. The fourth column gives the mean conductivity *k* for this temperature range in gram calories per second per inch cube per deg. C. Columns 5 and 6 give calculated values of the heat conductivities *k* at 100 deg. and 1000 deg. C. respectively.

While the calculated conductivities are in some cases not in close agreement, in general they are consistent in indicating the relative conductivities of the various materials. Taking the averages of the figures applying to each material the conductivities at 100 deg. and 1000 deg. C. are given in Table III, in gram calories per second per inch cube per deg. C.

Table III.

	Average *k* at 100 deg.	Average *k* at 1000 deg.
Woodland . …	0.0043	0.0086
Quartzite . …	0.0051	0.0086
Star Silica	0.0056	0.0108

For magnesite brick it was found that between 445 deg. and 830 deg. C. the conductivity of the magnesite brick was practically constant, the value being 0·0343 gm. calories per second per inch cube per deg. C. For this reason magnesite brick is not included in the above Table III.

It is estimated that the precision of the figures representing mean conductivities is within 5 per cent. The precision of the average figures representing the conductivities at definite temperatures is less, but it is difficult to estimate."—*Chemical and Metallurgical Engineering*, May, 1915, p. 315. (G. H. S.)

Wet Extraction of Mercury.—"Little has been done in recent years on the metallurgy of mercury except in improving the furnaces for distillation and the condensers. G. V. Northey used water concentration at the Manzanita mine for some time and reports success. Dr. Clifford G. Dennis recently made some tests on floating the cinnabar and got good results, considering the crude apparatus used. The small profits of the business, however, except to those having high-grade ore, have not been conducive to experiments involving any radical change in the treatment of ores. The present high price of the metal, due to its use in making explosives, has stimulated the industry to an extent not seen in years. Practically all foreign competition has been shut off and American producers are getting almost any price they demand.

At present, two methods are in use to obtain mercury from its ores on a large scale. One depends on the fact that at a high temperature the oxygen of the air combines with the sulphur of the mercuric sulphide, forming sulphur dioxide and metallic mercury. The other depends upon heating the mercuric sulphide with iron or lime, the sulphur combining with the iron or lime, setting the mercury free. The first method is carried out in shaft furnaces, usually of the continuous type, and is the more important of the two commercially. The second method is applied in retorts and is too expensive a procedure except for rich ores.

In spite of its universal application, the furnace method has disadvantages that will never be overcome. These are high cost of installation, quantity of soot caught with the mercury in the condensers, imperfect condensation, low extraction, particularly on low-grade ores, poisoning of workmen, excessive amount of mercury tied up in condensers, and the time required to place mercury on the market after the plant is put into operation.

The cost of building a continuous furnace of the type most used in California is approximately $1000 per ton of capacity. This figure would be excessive in some cases and low in others, but represents the average cost. On low-grade ores, 0.5%, or lower, the soot caught with the mercury in the condensers usually necessitates retorting the product. The brick work of the condensers absorbs mercury, and furnaces have been known to run from eight months to one year before any clean-up could be made. The actual investment in a furnace plant would not only be the installation cost of $1000 per ton of capacity, but would include operating costs until mercury could be placed on the market.

To those considering the installation of a furnace plant, to take advantage of the present high prices, the time required to put the mercury on the market is of especial importance.

These disadvantages led C. A. Mulholland to experiment with a hope of devising a wet process for the extraction of mercury, particularly from low-grade ores. It has long been known that mercuric sulphide is soluble in alkaline sulphides containing free alkaline hydrate, and Becker, in his monograph, 'Geology of the Quick-silver Deposits of the Pacific Coast,' made elaborate experiments to prove that the California deposits were due to the dissolving and subsequent precipitation of cinnabar from such solutions. The scheme of treatment suggested by Mulholland, deduced from his experiments, was to grind the ore in an alkaline sulphide solution, whereby the cinnabar was dissolved, separating the solution from the ore by filtration or decantation, precipitating the mercury out of solution with zinc hydrate, which brought down a mixture of zinc sulphide and mercuric sulphide, dissolving the zinc sulphide out of the precipitate with sulphuric acid, and retorting the remaining precipitate of mercuric sulphide to obtain metallic mercury. The hydrogen sulphide formed by dissolving the zinc sulphide was used to regenerate the sodium sulphide solution. The chemical reactions involved in Mulholland's scheme are :—

$$Na_2S+HgS=Na_2S.HgS$$
$$ZnSO_4+2NaOH=Zn(OH)_2+Na_2SO_4$$
$$Zn(OH)_2+2NaOH=Na_2ZnO_2+2H_2O$$
$$Na_2S.HgS+Na_2ZnO_2+2H_2O=HgS+ZnS+4NaOH$$
$$ZnS+H_2SO_4=ZnSO_4+H_2S$$
$$2NaOH+H_2S=Na_2S+2H_2O$$

The sodium sulphide solution was destroyed each time it went to precipitation and was regenerated by introducing the hydrogen sulphide formed when dissolving the zinc sulphide with sulphuric acid. The mercury was obtained from solution as the sulphide and was retorted with lime or iron.

Where the cost of mining is low, Mulholland estimated that mercury ores as poor as 0·3% could be worked at a profit by this process. No commercial application of this process has ever been made, to my knowledge.

The Buffalo Mines, at Cobalt, of which T. R. Jones is general manager, is at the present time using a wet method to recover mercury as sulphide from amalgamation tailing. This should be equally applicable to cinnabar ores. The mercuric sulphide is dissolved out of the tailing with sodium sulphide and the mercury precipitated on scrap aluminium. The chemical equations are :—

$$Na_2S+HgS=Na_2S.HgS$$
$$3Na_2S.HgS+8NaOH+2Al=3Hg+6Na_2S+2NaAlO_2+4H_2O$$
$$2NaAlO_2+Ca(OH)_2=2NaOH+Ca(AlO_2)_2$$

From the equation, 11 lb. mercury should be precipitated with 1 lb. aluminium. Practically the ratio is about 7 :1, as some hydrogen is given off during the precipitation. Not only is the sodium sulphide combined with mercuric sulphide regenerated, but the sulphur with the mercuric sulphide goes to form sodium sulphide. The caustic soda is regenerated by the addition of lime, which also assists settling or filtration. These points have all been verified by laboratory experiment and actual practice. With a clean cinnabar ore the mercury would be obtained wholly in the fluid form without retorting, and by straining through canvas it would be made ready for market.

Over 10,000 lb. mercury has been recovered by the Buffalo Mines by this process at a cost of approximately 13 cents per pound. The applicability of the process to cinnabar ores cannot be questioned, both as regards cost and recovery, and it should obviate most of the difficulties inherent in the distillation method. The cost of installation should not exceed $500 per ton of capacity. Since standard cyanide machinery can be used: crushers, pebble mills, Dorr classifiers, thickeners, etc., the plant could be erected in a minimum of time and mercury could be placed on the market in three to four days after the plant was put in operation.

The mercury produced at the Buffalo Mines by this process was assayed by Ledoux & Co., who reported silver only in determinable quantities. The sodium sulphide used cost $..25 per cwt. f.o.b. chemical works for the commercial crystals and the aluminium for precipitation consists of casting-foundry turnings costing $2.50 per cwt. f.o.b. foundry."—E. B. THORNHILL.—*Mining and Scientific Press*, June 5, 1915, p. 873. (G. H. S.)

THERMIT WELDING OF CAM SHAFTS. "Thermit welding of cam shafts at the Tonopah-Belmont mill cost $42.53 per shaft. The weld was turned down to the original size, and the shafts broke after 36 days' service. Another one was welded, but the boss of ½ in. high and 4 in. wide was left. This shaft is working well, the boss being in the middle bearing."—*Mining and Scientific Press*, Sept. 18, 1915, p. 447. (G. H. S.)

DETECTION OF BLOWHOLES IN CASTINGS BY X-RAYS.—"Though various methods of testing metals have been in use for some considerable time, such as chemical analysis, metallography, and mechanical and physical testing, no method, as far as the author of this note is aware, has been evolved until quite recently for detecting internal blowholes by external examination. Such defects being, in the ordinary way, only discovered when the material is subjected to machining, the application of X-rays for this purpose seemed likely to be of great service. Particularly is this the case with copper castings, since pure copper, when at a high temperature, absorbs gases from the air, thereby rendering likely the formation of blowholes. When making these castings a small quantity of phosphorus, tin, or zinc is usually added as a deoxidiser. Blowholes, however, are always to be guarded against, and in order to study their occurrence the author made some X-ray experiments upon a thin casting of pure copper, using a Gundelach X-ray tube.

The specimen which was used in the experiment was a plate of pure copper, cast at a high temperature. The plate measured 5 in.×4½ in.×¼ in., with a hole ⅛ in. diameter and 4½ in. deep drilled in one side. A channel 1/16 in. deep was drilled on the surface, in order to vary the thickness of the plate. The specimen was laid on the X-ray plate vertically under the Gundelach tube. By varying the vertical distance between the centre of the tube and the X-ray plate, the time of exposure, and the strength of current, the following results were obtained :—

No. of experiment.	Vertical distance	Time of exposure	Strength of current	Remarks.
	Centimetres	Min. Sec..	Milliamperes.	
1	50	2 5	0·8	Very faint spots obtained, which indicated the positions of blowholes
2	30	2 30	0·8	More distinct spots obtained
3	15	5 0	2·0	Much more distinct spots obtained, together with the radiograph of the hole in the sample

In order to verify the results so obtained, the plate was sawn across through the indicated positions of the blowholes, and these were found to be continuous.

In this experiment an X-ray source of ordinary strength was used, but had there been employed a much more powerful source, such as the Coolidge tube, used by Dr. Wheeler, the radiographs would certainly have been sufficiently distinct to determine the exact position of the blowholes. Moreover, by taking radiographs in two directions at right-angles to one another, the depth of the blowholes beneath the surface of the plate could be determined.

In conclusion, there is little doubt that useless work in the machine shop might be saved by testing metals by means of X-rays as described above." —C. H. Tonamy, Institute of Metals.—*Iron and Coal Trades Review*, September 24, 1915, p. 395. (G. H. S.)

Electric Smelting of Iron in Sweden.—"Electric production of iron is making rapid progress in Sweden, a country of large water-power development. There are 11 furnaces in operation, from that of 2,500 h.p. at Trollhätten to 10,000 h.p. at Domnarfvet. Kilowatt-hours consumed at the Trollhätten furnace per ton of pig-iron are 2,116; iron produced per horse-power year, 3·05 tons; and consumption of electrodes, 4·14 kgm. per ton of iron." *Mining and Scientific Press*, Nov. 20, 1915, p. 789. (G. H. S.)

Laboratory Agitation Vat.—"A vat equipped to use the Parral system of agitation, and of a size suitable for laboratories or small test-plants, may be cheaply made from an ordinary wooden barrel, as shown in the accompanying illustration, which is an acid-proof vat for experiments in leaching of copper ores :—

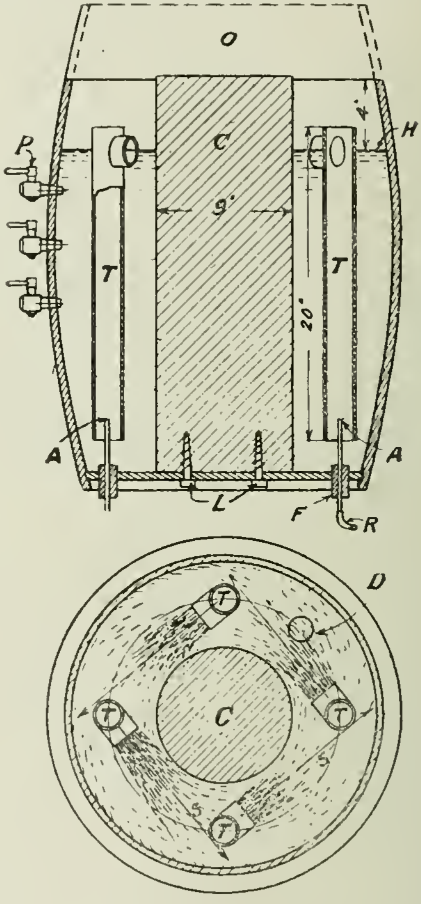
O. Is the top portion of the barrel, about 5 in. or 6 in. to be cut off.

C. Is a central filler made round from a solid piece of 10 in. × 10 in. timber. The object of this is to take up space in the vat so as to reduce its holding capacity, and therefore the necessity of pulverizing so much pulp for a test. A barrel equipped as shown has a holding capacity of 60 lb. of pulp, with 120 lb. of solution.

T. Is the transfer-pipes, which in acid-proof vats are of 2 in. lead pipe.

A. Is the lead pipe air-nozzle. This is inserted through a wooden plug F, which drives snugly into holes bored in the bottom of the vat, the lead nozzle extending up about 2½ in. into the transfer-pipes.

R. Is a rubber connection wired on to the air-nozzle. This connection extends upwards to the iron air-pipe placed above the pulp-level H.



Laboratory Agitation Vat.

P. Is the wooden plug-cocks which are fitted staggered into the side of the vat at various heights for drawing off the clear pregnant solution, when the solids are settled on the bottom of the vat.

D. Is a plugged hole in the bottom of the vat through which the treated charge may be drawn off.

The vat is set on a rock about 18 in. above the floor for convenience in making the bottom connections, and drawing off the charge. Similar vats with slightly different equipment suitable for making cyanide and oil-flotation tests may be made. Detail plans for the construction of experimental vats of any size suitable for testing ores by either acid leaching, cyanidation, or oil flotation will be furnished gratis by the Parral Vat System of Agitation, I. W. Hellman building, Los Angeles, California." *Mining and Scientific Press*, Nov. 13, 1915, p. 766. (G. H. S.)

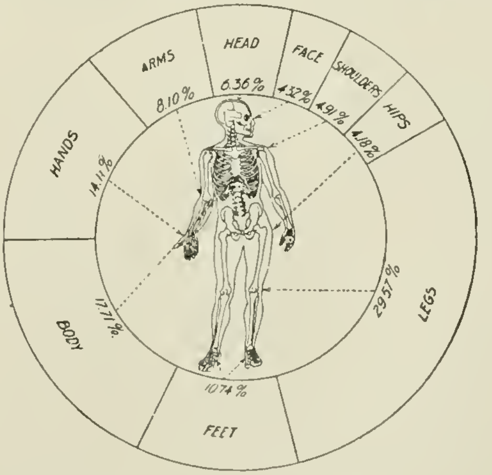
Electrolytic Zinc.—"Mr. John D. Ryan, president of the Anaconda Copper Company, has confirmed recent rumours that a large electrolytic zinc plant is to be erected at Great Falls. On Dec. 13 ground for the new works was broken, Mr. Ryan holding the plow and Mr. Ben B. Thayer driving the team while the first furrow was upturned, preparatory to clearing a site for the foundations. The new plant is to have a capacity of 70,000,000 lb. of spelter per annum and is to be completed by September next at a cost of $2,000,000. The decision to make this metallurgical departure is the sequel to a series of careful working-tests conducted under Mr. E. P. Mathewson's direction at the Washoe works. Of course, the choice of Great Falls as the site for the electrolytic plant is due to the fact that cheap electric power, of which 30,000 horse-power will be required, is available there. from the Missouri river. The experimental plant at Anaconda began operations in October, it has a capacity of 10 tons daily, but the actual output of zinc has been only three or four tons per day owing to the lack of an adequate concentrator for zinc ores. We understand that the refinery will be enlarged immediately to 25 tons capacity. Meanwhile another interesting step will be taken, namely, the building of a concentrator of 2,000 tons daily capacity, using the Minerals Separation process of flotation, which will then supply zinc concentrate for both the zinc refinery at Anaconda and the one at Great Falls. As regards the treatment of the zinc concentrate, the process is a modification of the old sulphate roast as worked out by Mr. Frederick Laist and his assistant, Mr. F. F. Frick. The ore is first oxidized by a gentle roasting and is then leached with dilute sulphuric acid. Impurities in the solution are precipitated, the iron by means of limestone, the copper and cadmium by means of zinc. The main thing is to get a pure solution of zinc sulphate; this is then electrolized, using insoluble lead for anodes and either aluminum for cathodes or starting-sheets of zinc that have been deposited on aluminum sheets and then stripped. After the zinc has been removed from the electrolytic vats it is melted in a small reverberatory furnace in lots of a few tons and ladled into bars of 50 lb. each.

Electrolytic zinc, being practically free from impurities, is extremely tough and particularly suited for the manufacture of the highest quality of brass, such as is used in munitions. In our issue of January 2, 1915, we published a description of another electrolytic method of zinc precipitation, as conducted at Palo Alto, California, by means of the Carl Hering patent, the idea of which is to employ an electrode able to combine with, and thereby remove, the impurities in the zinc sulphate solution. This is supplemented by the purification of the zinc sulphate solution by means of evaporation and crystallization. The plant at Palo Alto has treated small lots of baghouse fume from the Shasta county smelters and has produced some spelter of unexceptionable purity. However, the thickness of zinc precipitated has been so small as to interfere with practical success. Other experiments have been in progress in Shasta county, by the Bully Hill company, on lines similar to those of the process now successfully developed in Montana, save that the leaching is done with the acid electrolyte, so that the amount of sulphuric acid remains practically constant in the cycle of operations. Here also the experimental work has progressed to the point where the construction of a large plant is justifiable. We are informed that such a plant is to be erected within the next six months. This will lead to the resumption of smelting at Balaklala and Bully Hill. But the fact remains that the problem was solved first at Anaconda. This is an event of supreme metallurgical importance, for it marks the doom of the old retort furnace and the clumsy distillation methods hitherto in vogue in Europe and America. Combined with successful concentration of the by-product zinc in copper, lead, and precious-metal ores by means of the flotation process, this radical change in the metallurgy of zinc will have far-reaching effects. The precipitation of the zinc from an ordinary complex ore yields a concentrated residue readily amenable to ordinary lead or copper smelting practice. Instead of the minor zinc content being the excuse for the exaction of a heavy penalty by the smelter, it will be a saleable by-product. This beneficiation of the zinc hitherto worse than valueless will cause a cheapening of the metal and a further extension of its use in the arts, especially in the galvanized iron industry."—*Mining and Scientific Press*, Dec. 25, 1915, p. 950. (G. H. S.)

Stainless Steel.—"'Stainless' steel for use in instruments or cutlery where rusting or tarnishing are especially deleterious is now manufactured in England. Sir Robert Hadfield at a meeting of the Faraday Society indicated that a typical analysis of the steel is: chromium 12·7%, iron 86·6, carbon 0·28, silicon 0·01, manganese 0·12, cobalt 0·45%. Experiments are being conducted to determine this steel's resistance to acids, sea-water, etc."—*Mining and Scientific Press*, April 22, 1916, p. 602. (G. H. S.)

MINING.

Body Chart for Non-Fatal Accidents.—"A body chart, or diagram, showing the percentage of non fatal accidents to different parts of the body, arranged from a tabulation of 6,719 non-fatal injuries from accidents at coal mines, has



Percentage of Non-Fatal Injuries Received by the Body in Mining Accidents.

been prepared by the Bureau of Mines and is contained in a pamphlet entitled 'Coal Mine Fatalities in the United States, 1915,' compiled by Albert H. Fay. It will be seen from the illustration that practically 30% of the accidents at coal mines result in injuries to the legs, and that injuries to the hands amount to 14%, and other parts of the body as shown. This diagram was prepared to aid surgeons and hospitals in selecting the necessary supplies for use at coal-mine hospitals and should be as applicable to metal mining as to the purposes for which it was prepared."—A. H. Fay.—*Engineering and Mining Journal,* June 10, 1916, p. 1030. (H. A. W.)

MISCELLANEOUS.

The Organization of Scientific Research.—"*Summary.*—The author deals with the methods of scientific research, with the means of conducting research, and outlines a suitable training for the men engaged in scientific and industrial research.

In the last 40 years, there has been a slowly progressive enlargement in the provision made within the British Empire for conducting and encouraging scientific research, though by no means proportional to the necessity for it. Amongst the indirect results of the appalling war, we may hope that there will be some increased appreciation in the minds of the politicians, who govern us, of the enormous influence of scientific research and discovery, even in its most abstruse forms, on the prosperity and safety of the Empire.

The public is too prone to judge of the success or value of scientific work by the degree to which it can be immediately applied in what are called useful purposes. They require to be instructed that we cannot produce merely the knowledge which is instantly utilisable in common life. Practical invention is much affected by other factors, such as our patent laws, fiscal policy and wise or unwise commercial legislation. These will require thoughtful revision in view of coming competition. The question obviously divides itself into three sections—(1) Method, (2) Means, and (3) Men.

I. Methods of Scientific Research.

The great bulk of all our scientific discovery and research in the past has been due to individual labour and initiative; much of it a labour of love, unrecognised at the time. Men of great genius have opened up new lines of thought or pursued private researches often with very inadequate appliances. In fact, the greater part of past British scientific research may be said to have been amateur work, not in the sense that it was lacking in the highest qualities, but only in the sense that it was pursued for the sheer pleasure and interest of it by private individuals. The author refers to the necessity for co-operation in scientific work, and states this is already being done by the British Association and Faraday Society to some extent. Also, scientific societies should at the beginning of each session direct attention to important matters.

The White Paper, which was issued last July by the Board of Education, signed by Mr. Arthur Henderson, seems intended to bring into existence some machinery for effecting this desired end. So far as the 'Scheme for the Organization and Development of Scientific and Industrial Research,' outlined in this White Paper, is formulated in detail, it appears to consist in the establishment of (i.) a committee of the Privy Council, which will be responsible for any expenditure voted by Parliament for scientific and industrial research; and (ii.) a small advisory council, composed mainly of scientific men and men actually engaged in industries dependent upon scientific research.

The primary functions of the Advisory Council are stated to be to advise on :—

1. Proposals for instituting specific researches.
2. Proposals for developing or establishing special institutions for the study of problems affecting particular industries.
3. The establishment and award of research studentships and fellowships.

The White Paper tells us that it is contemplated that the advisory council will work largely through sub-committees reinforced by suitable experts in the particular branch of science or industry concerned on which it would be desirable to enlist the services of persons actually engaged in science, trades, or manufactures.

It is clearly impossible for any single board composed of a few men, however eminent, to deal in any reasonable time with all the research problems awaiting solution in physics, inorganic, organic and technical chemistry, metallurgy, engineering, electrotechnics, bacteriology, agriculture, etc., and the questions concerned in the recovery of our trade in dyes, drugs, glass, ceramic ware, ferro-alloys and scientific apparatus. Hence separate bodies of experts will unquestionably be required to deal with the different subjects in order to bring to bear upon them the proper technical knowledge and to guide research on the right lines. But now, if this is the case, the question at once arises: Why is it necessary to create new machinery for dealing with these matters?

The proposition I submit for your consideration is that the organization of scientific research should be a matter undertaken by scientific men themselves, and should not be taken over independently of them by a Government Department. The essential matter is that this organization of scientific research should not become bureaucratic or academic, but should be conducted by bodies representative of the best technical and scientific opinion, and be closely in touch with the members of each of the several scientific and technical societies. If public funds are to be administered, then it might be proper that certain of the members on each board should be appointed by the Government Department concerned, say, by the Education Department, but my contention is that the organization work should be the work of scientific men as a whole and not any small section of them, or be carried out by Departmental officials over their heads.

Suppose, then, we assume that we have created permanent advisory committees for the different branches of pure and applied science, the duty of which should be the organization of research in the irrespective departments. Their first work should be to draw up as comprehensive a report as possible, pointing out the general needs of each department of knowledge and the most necessary directions of research. The first report would, no doubt, have to be concerned chiefly with the deficiencies in the appliances and means of correcting it, such as laboratories and apparatus. Also with the number, and supply, of men available for or actually engaged on research work. Subsequent reports would then be properly occupied with the more detailed discussion of the problems awaiting investigation and particular suggestions for directions of research. These advisory boards would have then to be supplemented by some means for carrying out their suggestions into practice.

The author next deals with the position of the scientific man employed in a works, and with the difficulties which arise, such as patent rights, and expresses the view that some scheme of profit sharing is undoubtedly the fairest, and the best, to couple together the interests of all parties. He dismisses the idea of the State rewarding a scientific man by a pecuniary prize owing to the difficulties which arise. Who, for instance, could have set a value on Faraday's discovery of induced currents or magneto-electric induction, when in 10 days of unintermitting work at the Royal Institution in the autumn of 1831 he gathered in new knowledge of surpassing importance to mankind? These facts had no apparent value at the time, yet their application has brought wealth in untold millions into the exchequer of nations.

I remember speaking, shortly after Clerk Maxwell's death, in 1879, with an eminent Cambridge mathematician concerning Maxwell's great paper published in 1865 'On the Dynamical Theory of the Electro-magnetic Field.' He told me in all seriousness that the impression produced on his mind by this great paper was, that it was one of the most exalted productions of the human intellect. Yet it was 20 years, and long after Maxwell's death, before this paper brought forth its fruit in Hertz's work, and 35 years before we saw the final outcome of it in the achievements of wireless telegraphy. I believe the only practical method of assisting scientific research is by a well-devised system of research scholarships and fellowships renewable annually or at longer intervals, and in any case held subject to productive work. If we combine such a system with the above suggested advisory boards, there is a possibility of creating a workable system for the endowment and encouragement of scientific investigation which will be kept in close contact with practical necessities as well as with the most fertile regions of scientific thought. The important question is, then, the ways and means.

Deferring for a moment the consideration of the training of the men necessary for conducting research, we may consider in the next place :—

II. Provision of Means for Conducting Scientific Research.

By this is meant the materials and apparatus required. In early days these were simple and comparatively inexpensive. Much great work has been done with simple apparatus. Nevertheless, our modern scientific research requires, for the most part, costly appliances.

One rather startling experience at the outset of this great war was the discovery of the extent to which we had become dependent on Germany and Austria for these implements of research. We found that our sources of supply of chemical glass, such as flasks, beakers, tubes, graduated vessels, and more complicated pieces of analytical apparatus was cut off. Also porcelain crucibles, basins, tubes, and retorts, filter papers, and large numbers of research chemicals were not produced in England of the requisite quality. Amongst pharmaceutical chemicals, a very large number have been unobtainable, or obtainable with difficulty, since the war—such as salicylates, salvarsan, veronal and phenacetin. This partial famine in essential scientific materials and apparatus is not due to any real want of scientific ability on the part of British inventors or manufacturers. It is due to causes which are very deep-seated. For one thing, our easy-going national temperament has found it less trouble to buy from abroad than make for ourselves. Labour difficulties, our fiscal policy, and other causes have rendered it difficult to compete with German prices.

Above all, the mistake and ignorance of politicians who allowed themselves and others to believe that there was no real danger of a rupture of peace, and that Germany's tremendous preparations for war had no other object than defence against sudden attack by jealous neighbours, acted like an opiate on our spirit of commercial enterprise and dulled our instinct of self-preservation. Meanwhile it is to be hoped we are now awake to facts, and that our scientific men, manufacturers and statesmen will unite in remedying the present serious condition of affairs.

Now, the question is—are we going back, when peace returns, to the old easy-going habits of importing German-made scientific apparatus? Surely the answer is No! a thousand times No! But unless we wish Germany's crime-stained hands to take back in commerce what she has lost in war we have to create and maintain an entire scientific and economic independence of our own. For this purpose we need, for one thing, a properly-complete Scientific Intelligence Department. The different agencies, committees and institutions which have been endeavouring to supply scientific information as to manufactures should have as their resultant a single organization, the function of which should be to collect and distribute all possible information concerning the mode of manufacture and cost of production and information concerning the patent position, if any, of all the appliances and materials used in scientific research. Such a scientific intelligence and information bureau might need subsidising at the start, but it might be possible later on to make it self-supporting by the subscriptions of firms and persons who desired information on particular matters. Just as one can pay a fee to a patent agent to conduct a search for anticipations on some particular subject, so this information bureau should have as its object to collect and supply to its subscribers all possible information concerning the manufacture or supply of the materials and implements of scientific research.

There are already the beginnings of such a scheme in the information published by the Institute of Chemistry on reagents for analytical purposes prepared by a special committee appointed by the Institute and by the Society of Public Analysts and other Analytical Chemists. There is also an association called the British Laboratory Ware Association, formed by various firms to stimulate the production in this country of various laboratory requisites hitherto mainly produced in Germany. The means that shall be taken to prevent this nascent national production of the materials of research from being killed by subsequent German competition is a question to which our political economists and statesmen must address themselves very seriously. It is only a small part of the great problem of our post bellum commercial policy in relation to the British Empire and our Allies, but the consideration of it lies beyond our present purpose. We have then to consider :

III. Training of Men Necessary for Conducting Research.

Whilst the highest achievements in scientific research and invention must always depend to a great extent on that indefinable quality we call genius, which cannot not be made to order, it can hardly be doubted that much can be done to foster and assist research and invention. The nation must be educated to see that the men with high scientific and inventive ability, not by any means too numerous, constitute a national asset of inexpressible value. This power, when it exists, should not be allowed to dissipate itself in a struggle to secure the means of living, but be given an opportunity for the fullest exercise and use. There can also be no question that we have it in our power by suitable methods of education to develop such nascent ability. Our present systems of education, and particularly the system of written examinations which are dependent so much on good memory for success, do much to destroy originality. The great outstanding fact in modern life is the degree to which the energies and materials of Nature are employed to overcome the difficulties created by the increase and concentration of population. Hence an absolutely essential part of any complete education is some knowledge of science, and especially of its influence on the welfare of mankind. Yet the people we put in a position of authority over us are, for the most part, not only ignorant of science, but not even interested in it.

The Public Schools and Law Courts are then dealt with. The destruction of the madder and indigo industries by German synthetic research is referred to as showing the effect of science on industry of a country, and it is urged that we ought to create a very much closer union between industry and science. To some scientific men this seems derogatory to the dignity of science. On the other hand, men concerned with the business side of manufacture are apt to undervalue the aid which science can give them. Meanwhile our scientific industries suffer from this dissociation.

In the first place, we should aim at bringing about a much more intimate relation between the universities and technical colleges and the factories and workshops, so that the college teaching may result in producing a type of man useful in the factory. For this reason I am an advocate of the so-called sandwich system, by which the student spends a year alternately in the shop or factory and in the college, the first and third year being at the college and the second and fourth in the shop or factory. This turns out a better type of man than two years at the college and two years in the shop taken consecutively. It should apply not only to engineers in all branches, but to chemists as well.

Then, again, conferences should be held from time to time between teachers and practical engineers and chemists for the exchange of ideas on the subject of the schemes of work and study to be followed by the student-apprentice, so as to turn out all-round men and not unpractical theorists or unscientific practists. We have to improve in many ways our college teaching, so as to expend to better advantage the available time, and place more stress on ability to use information than to store it. One result of the war and of the economic pressure which will follow, will no doubt be to diminish the time given to amusements and games at both schools and colleges.

In the discussion which followed, Mr. J. S. Swinburne, F.R.S., said he did not see how a discovery made in this country and published would help us if other nations could copy it. There was a confusion between scientific research, industrial research and invention. After contrasting the different way of viewing things in this country and in other countries, he expressed agreement with the author that any kind of research in the hands of the Government was useless. A committee was quite useless—ordinary committees were bad enough, but Government committees were infinitely worse. He did not consider the author's suggestions about research practicable—research was dull work. He thought that students should be trained in economics, next the State must not lay its deadening hand on industrial advance, the student should be trained in principles at college, and do their research work in the works. The Patent Laws should be revised, not by politicians and lawyers, but by the people concerned."—J. A. Fleming, D.Sc.—*Australian Statesman and Mining Standard*, June 15, 1916, p. 409. (H. A. W.)

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Aimetti, S., *l/o* Pilgrims Rest; Cogill's Hotel, Wynberg, C.P.

Bell, H. D., *l/o* Krugersdorp; Metallurgical Department, Rand Mines, Ltd., P.O. Box 1056, Johannesburg.

Donkin, H. F., *l/o* Germiston; No. 9921, 4th Regiment, 1st S.A. Infantry Brigade, Borden, England.

Fraser, C., *to* Maude Reefs G.M. Co., Glen Wills, Victoria, Australia.

Howard, T. C. L., *l/o* Rhodesia; c/o African Banking Corporation, Ltd., London, E.C.

Jolly, T. S., *to* Ferreira Deep, Ltd., P.O. Box 1021, Johannesburg.

Lee, W., *l/o* Zoutpansberg; Broken Hill Mine, Northern Rhodesia.

Richardson, R., *l/o* Rhodesia: Pilgrim Street, Barberton.

Thorburn, J. M., *l/o* Johannesburg; Wanderer G.M. Co., Selukwe, Rhodesia.

Womble, L. A., *l/o* Springs; 85, St. George's Road, East London, C.P.

APR 1 5 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII NOVEMBER 1916. No. 5.

Proceedings
AT
Ordinary General Meeting, November 18, 1916.

The Ordinary General Meeting of the Society was held in the South African School of Mines Building, Johannesburg, on Saturday, November 18th, 1916, Prof. J. A. Wilkinson (President), in the chair.

There were also present:—

22 Members and Associates: Messrs. J. Gray, G. Hildick Smith, H. A. White H. R. Adam, J. Chilton, F. G. Macdonald, H. S. Meyer, C. Toombs, F. Wartenweiler, F. W. Watson, John Watson, Dr. W. A. Caldecott, A. McA. Johnston, Prof. G. H Stanley and J. E. Thomas (Members of Council), W. J. Abel, R. A. Cooper, H. S. Kenney, G. Melvill, Dr. A. J. Orenstein, C. B. Simpson and T. P. Waites.

3 Associates and Students: Messrs. R. W. Irwin, C. H. Olsson and J. A. Woodburn.

4 Visitors and Fred Rowland (Secretary).

MINUTES.

The Minutes of the last Ordinary General Meeting, held on Saturday, 21st October, 1916, were confirmed.

ELECTION OF NEW MEMBER.

Messrs. Hildick Smith and F. W. Watson were elected scrutineers, and after their scrutiny of the ballot papers, the President declared the following gentleman unanimously elected to membership:—

MEIKLEJOHN, CLAUDE A., Rand Mines, Ltd., P.O Box 1056, Johannesburg. Metallurgist.

ROLL OF HONOUR.

The President: It is with great regret that I have to announce the death of another one of our Associates on active service. I refer to Major W. H. Pickburn, of the S.A. Heavy Artillery, with whom probably many of you were acquainted. There is no need for me to dilate on his good qualities, or on the fact that we have lost another, whom we can ill spare. I would ask you to pass a vote to his memory, standing.

All present rose to their feet.

GENERAL.

EAR DEFENDERS.

Mr. A. J. Herald *(Member)*: The following note may be of interest to those members, whose duties require them to spend a large part of their working day in the noise of a stamp mill. The ear defenders consist of two small vulcanite plugs, as shown by the samples here, shaped much like "Halma" pieces, to fit into the ear. A hole goes through the length and at the enlarged bell mouth end a fine wire screen is fixed. This screen breaks the waves of sound.

A pair of these ear defenders, designed for use by artillery men, was tried by an experienced mill man in the stamp mill of the Knights Deep for several months. After becoming used to them the operator reports, that he can hear a person talking quite clearly, can more easily detect the sound made by a broken stem or any unusual noise different from the steady roar of the stamps. Other advantages are that within a few minutes of going off shift the hearing becomes normal, and that there is an absence of the usual buzzing sound in the ears for a considerable time after leaving the mill.

In the usual practice of using a plug of cotton-wool, or what is worse, cotton waste, threads or pieces are liable to stick to the wax of the ear, and cases have occurred where medical aid had to be sought to remove the obstruction. No such trouble can arise with these defenders, as they are shaped to fit the ear, and have no loose material likely to be detached.

The shiftsman, who used the defenders, was loth to hand them back after the trial, and it would appear, that they are a useful acquisition to the stamp mill worker. When obtainable locally, there is no doubt that the defenders will become generally used.

Mr. A. McArthur Johnston *(Past-President):* In addition to what Mr. Herald has said, I might mention that Dr. A. H. Watt reports on these Ear Defenders, that, so far as he could make out, no damage would result to the ear drums by their use. Personally speaking, I should like to see the part entering the ear made of a softer material. They are made in three different sizes.

Mr. J. E. Thomas *(Past-President):* I might say that these "Ear Defenders" were handed to me for trial. I gave them to one of the mill shift-bosses, who confirms the statement made by Mr. Herald, and further, says that the sound on the cam-platform, when wearing the defenders, is much the same as in the mill office, which is fitted with double windows, and that although the sound made by the stamps is quite distinct, one can hear any unusual noise. He also reports that his hearing became quite normal within a short time of leaving the mill.

Mr. F. Wartenweiler *(Member of Council):* I can corroborate the testimony given in favour of these Ear Defenders. I have used them, off and on, for some months, and find that they aid one in hearing any unusual noise in the battery, such as broken stems, or iron on iron; and they certainly do deaden the sound of the battery.

INDUSTRIAL RESEARCH.

The President: In the annual report of last year reference was made to the conference of the scientific societies convened by the South African Institution of Engineers on June 8th with the object of discussing the methods to be adopted for the promotion and organisation of scientific research, with especial reference to the initiation of new industries in this country, and the improvement of those already in existence.

The necessity for such a step was manifest, as the large attendance and keen discussions, both at and since the conference, have most conclusively proved. The immediate result of the conference was the appointment of a central committee, composed of three representatives, to be elected from and by the Council of each of the societies, which accepted the invitation to the conference. The representatives elected by your Council were Dr. Caldecott, Prof. Stanley and myself. On the 29th June the central committee held its first meeting, and appointed from its members an executive of five, to which one of your representatives, Dr. Caldecott, was elected. The first activity of this executive was to call for recommendations from the representatives of each society on specific questions of the most essential and urgent importance; and your Society collaborated with the representatives of the South African Association of Analytical Chemists, Drs. Moir and McCrae and Mr. J. A. Campbell, and a joint report was submitted.

These collected reports were collated by the executive, and, as great stress had been laid on the fact, that a Government Department should be constituted, to deal with the problems which, in the opinion of the majority demanded attempts at immediate solution, more especially the question of research facilities, an interview was sought and obtained with the Hon. Mr. Malan, Minister of Mines and Industries, at which a preliminary discussion of the more important issues took place. Subsequently, on the 29th September, the Executive were granted a second interview, and the resolutions of the central committee were placed before him.

Meanwhile an Advisory Board of Industries and Commerce was appointed by the Government to deal with the whole question of local industries, upon which the Executive committee pressed for a large representation of the Central committee, in order that the importance of research should be strongly emphasised, and receive the position, to which its importance entitled it. The Minister, however, stated that under present circumstances it was impossible to appoint more than one member, and at a meeting of the central committee, on the 9th October, Prof. Stanley, one of your representatives, was nominated, and later duly appointed as a member of the board.

The first meeting of the Industries' Advisory Board took place on October 17th, at Union Buildings, Pretoria, when the Minister took the opportunity of outlining the work for which it had been appointed. From the report of this speech, as given in the *Rand Daily Mail*, of October 25th, the Minister stated that "the main object of this Board will be to advise the Government on industrial questions, and to encourage industries—to assist existing industries and find new ones; to obtain as far as possible statistics and information; to bring forward recommendations for scientific industrial research; to give advice regarding industrial legislation proposed by the Government; to investigate proposals which come before the Government from time to time concerning particular industries, and to advise parties who require assistance in fostering industries in the Country, and what can be done to further their development; to investigate the available raw material existent within the Union from an industrial point of view; to consider proposals for the greater utilisation of the plants and trees within the Union. Finally, the Minister stated that the Government was anxious to develop the resources and industries of the country, and what could be done within reason would be done."

This brief resumé of the present situation with regard to the work already accomplished in this direction will serve to keep members in touch with what we hope will prove to be one of the most important phases of scientific work ever undertaken in this country. There do not at present exist here industries, except in one or two isolated instances, such as are connoted by this term in older countries. The largest chemical industries are explosives and soap, and in these cases the greater bulk of the raw material requires to be imported. The industries upon which the research committee places such emphasis, and of which the Minister speaks, are those which are primarily dependent for their existence and take their origin from such raw materials, as exist within the Union itself. For this purpose, therefore, it is obvious that we must know and learn what these raw materials are, where they are to be found, and of what they are composed. This, then, is the first step, a complete realisation of our resources, in other words, as full an economic and chemical survey as is possible. When we have arrived at this stage, we shall then be in a position to realise in greater or lesser degree the possibilities of further industrial development in this Country. At the present moment we are dependent on exports from other countries for almost everything we use in our own daily life. Even with the small knowledge we possess at present, we feel that there is no necessity for such a state of affairs, since with right direction and proper knowledge a large number of these commodities could be manufactured here. And this sentiment must with the fuller knowledge gained by such a scientific assessment, as that mentioned above, give way to an essential sureness, which will direct our business men to commercial and profitable realisation. Side by side with this, however, there are existing industries to whose assistance science can lend her bounteous hand, and in this direction your research committee contemplates rendering such help, as to effect and ensure great improvements in production. The results of the intimate relations of science and industry in other countries, more especially in Germany and America, are too well known to permit of any other conclusion and we must not, therefore, disregard the lessons they can teach. This brings us to the point that must be clearly borne in mind, when once the activities of the committee are in being, namely, to effect the closest co-operation between all the scientific associations, boards or committees which have similar or corporate objects within the Empire and Allied Countries. In this connection it would appear that the transference of the Imperial Institute in London to the Colonial Office is about to result in a survey of the commercial products within the Empire. Technical committees have been appointed and are now at work co-ordinating and extending the operations of the Institute in ascertaining, valuing and bringing to the notice of manufacturers the raw materials of every country of the Empire. Timbers, rubber, silk, mineral resources, tanning material, are some of the investigations at present in progress.

In conjunction with the technical committees is working a committee of representatives of the principal Chambers of Commerce to secure co-ordination with the business houses throughout the country. On the other hand, the Committee of the Privy Council for Scientific and Industrial Research has formed three standing committees to deal with specialised branches of industry and to co-ordinate researches therein. The value and indeed the necessity for research work is being slowly recognised in England, but when the initial difficulties have been surmounted, its progress will be rapid and its effects far reaching. Here, in South Africa, we must not, nor do we intend to lag behind, and if we ask others to give us the benefits of their experiences, we must be able to offer in return. Action is for our good, and reaction for our greater good, and this is true of every part of the great Empire, to which we belong. If it be possible for me to interpret the feelings which we, as members of this progressive Society hold, I would say that we await with eager expectation the day when the survey of our resources is completed and industrial research an accomplished fact, in brief, *facta non verba*.

Mr. H. A. White *(Vice-President)*: In regard to the President's remarks with reference to the Advisory Board and the pursuit of technical research generally, I would like, briefly, to remark that we have just listened to the publication of the banns of marriage between Science and Industry, and I beg to call attention to the fact, that the Government is not the only priest which is capable of performing that union. To come to a more practical matter, I think we might ask our representatives on the Advisory Board, and on the Central Committee, to press for a further grant from the Government to the Seymour Memorial Library, in order that we might increase our stock, especially of industrial technical literature, which would be most beneficial at this present time.

The President: I thank you very much for making the suggestion, because I feel sure that coming spontaneously from a general meeting of members, such as this is, such a suggestion will be welcomed by my fellow members on the Central Committee, and we will take such steps as are necessary to further it.

INVITATION TO BANTJES CONSOLIDATED MINES CENTRAL SHAFT.

Mr. G. Hildick Smith *(Vice-President)*: Some months ago I arranged for any members who would like to do so, to visit the Central Shaft at the Bantjes Consolidated Mines to see an interesting piece of work being done there. Unfortunately none of our members have, up to the present, been to see this work. The original invitation is still open, so if any members would still like to see the re-opening of a portion of this shaft through very loose ground near the surface, if they come out to the mine between the hours of 9.30 and 11 any Saturday morning, I shall be pleased to show them round. The work is quite interesting, because it is a novel form of "spiling."

NEUTRALIZATION EFFECT OF ASH ON ACID-SAND IN STOPE FILLING.

By Chris. Toombs (Member of Council).

Some time ago it was decided to extend underground sand-filling operations at the East Rand Proprietary Mines, by utilising the sand from one of the dumps for that purpose. The sand dump selected as being the most convenient was the oldest on the mine, that at the New Comet Section. A trial run was made by the ordinary water-borne methods, but troubles due to its extreme acidity arose, which would be too costly to deal with by means of ordinary neutralizing agents, such as lime or crude soda carbonate.

One sample of the water carrying this sand underground gave a total available acidity of 1·71% sulphuric acid, requiring 160 lb. air slaked lime containing 60% calcium oxide per 1,000 gallons. (By total available acidity is meant sulphuric acid + ferrous and ferric sulphates.)

To overcome this difficulty and large expense, a novel scheme was suggested, which was to mix ordinary ash from the ash dumps, with the acid sand, and send both underground as filler.

It may not be generally known that most of our Transvaal coals when burnt give an ash containing lime, the lime contents varying with the percentage of residual ash. When the ash is fresh from the furnaces, the lime is present in the form of calcium oxide, samples giving from 25 lb. to 40 lb. calcium oxide per ton of ash, by sugar solution test, being found at one of our boiler plants. At another plant where mechanical stokers are installed and combustion of the coal is almost complete, the lime was found to have combined with silica, forming a clinker which had practically no acid-neutralizing powers.

After the ash has been exposed to the weather on the dump for a short time, the calcium oxide is all converted into carbonate, and tests by the sugar method on comparatively new ash, gave very little calcium oxide.

A short account of the experimental work carried out before the scheme was put into operation may be of interest.

Ash.—Several samples of ash from the various ash dumps were obtained and their acid neutralizing powers tested as follows:—1,000 gm. of ash were stirred up for a couple of minutes with 2,000 cc. semi-normal acid, when some of the acid was drawn off and tested, the loss in strength of the acid being calculated into lbs. calcium oxide per ton of ash.

The test was rough, but sufficiently accurate for the purpose required. The following results were obtained:—

A	48 lb. CaO	per ton.
B	58 lb.	,,
C	33 lb.	,,
D	13 lb.	,,
E	2 lb.	,,
F	12 lb.	,,

Sample D was a badly burnt coal.

Sample E, new ash from mechanical stokers.

Sample F from ash dump from same mechanical stokers as E. The higher result compared with E may be due to disintegration of calcium silicate on exposure to weather.

Sand.—Several samples of sand were taken from a cutting in the dump, and their lime consuming powers determined. The lime consuming substances in the old dump sand are sulphuric acid, ferric and ferrous sulphates, varying in proportion, and in relation to one another according to whether the sample was taken deep or near the surface. An average of several samples, calculating the iron salts as sulphuric acid, gave a total acidity of about 1·1%, requiring about 20 lb. air-slaked lime containing 60 CaO, per ton of sand. On a basis of 1,000 tons of sand per day, 10 tons air-slaked lime, costing £25, would be required to give a neutral overflow and drainage water.

Sand and Ash.—From the above determinations, calculations for a neutral mixture of sand and ash were made, and a few experiments with 50 lb. lots of sand carried out. The quantities of sand and ash were weighed and thoroughly mixed with water in a small tank, the water was drawn off and leached through several times, then tested. It was found to be neutral, or slightly alkaline to methyl orange, pointing to the elimination of free sulphuric acid. It had an acid reaction with phenolphthalein, and on examination was found to be free from ferric sulphate, but contained ferrous sulphate in abundance. Further experiments were made with an increasing ratio of ash to sand, but the ferrous sulphate was found to remain unpreciptiated. A further couple of experiments with fresh ash from the furnaces proved more successful, giving a water free from acid and salts of iron. Knowing that the difference between the fresh ash and that from the dump was, that in the new ash the lime existed as oxide, but as carbonate in that from the dump, the only theory one could establish was that ferrous sulphate in solution was not precipitated by calcium carbonate.

To prove if this theory was correct, further experiments with made up solutions containing sulphuric acid, ferric and ferrous sulphates were done. Various forms of calcium carbonate were tried—powdered limestone, powdered calcite, and precipitated calcium carbonate—the result in each case being the same, sulphuric acid and ferric sulphate eliminated, ferrous sulphate remaining. A long tube was filled with granular pieces of very soft limestone, and the solution passed through it repeatedly, the ferrous sulphate remaining at the end of a considerable period.

These ferrous sulphate determinations, I may mention, were not quantitative, but were made qualitatively to obtain sufficient knowledge for the successful carrying out of the work in hand.

The conclusion that one must come to from these experiments is that ferrous sulphate in solution does not react with calcium carbonate, and that the use of calcium carbonate for neutralizing acid underground waters will not achieve all that should be desired, viz., the elimination of all acid and acid-producing substances.

I may relate here that some time ago a sample of very finely powdered limestone was submitted to us for examination with a view to use on our underground waters. The results obtained with it were excellent, but analysis showed that it was not limestone, as it contained about 30 calcium oxide. A mixture of calcium oxide and calcium carbonate would not be economical, as the former being soluble and more chemically active would react at once with the sulphuric acid and ferric sulphate, leaving a large proportion of the carbonate unused.

The fact that ferrous sulphate in solution does not react with calcium carbonate was new to me, and several chemists to whom I spoke, said that they would expect these substances to react, giving a precipitate of ferrous carbonate. Dr. Moir explained their non-reaction by saying that FeO as the base in $FeSO_4$ was stronger than CaO as the base in $CaCO_3$.

Following are the details of some of the experiments made with mixtures of sand and ash:—

A.

Sand requiring 21 lb. lime per ton.
Ash from dump containing 40 lb. $CaCO_3$ per ton, and CaO 0·7 lb. per ton.

	Mixture.	Result.
(*a*)	100 sand 20 ash	Free acid and ferric sulphate gone. Ferrous sulphate left requiring 11 lb. lime per ton of sand. Saving in lime 10 lb. per ton of sand.
(*b*)	100 sand 40 ash	Ferrous sulphate left requires 7¾ lb. lime per ton sand. Saving in lime 13¼ lb. per ton sand.
(*c*)	100 sand 60 ash	Ferrous sulphate left requires 5 lb. lime per ton of sand Saving in lime, 16 lb. per ton sand.
(*d*)	100 sand 80 ash	Further lime required is 2½ lb. per ton of sand. Saving in lime, 18½ lb. per ton.
(*e*)	100 sand 100 ash	Further lime required is 2¼ lb. per ton of sand. Saving in lime, 18¾ lb. per ton.

B.

Sand requiring 20 lb. lime per ton.
Fresh ash containing 38 lb. CaO (by sugar test) per ton.

	Mixture.	Result.
(*a*)	100 sand 100 ash	Drainings strongly alkaline. No iron left in solution
(*b*)	100 sand 50 ash	Drainings neutral, but contain ferrous sulphate.
(*c*)	100 sand 75 ash	Drainings just alkaline, no ferrous sulphate.
(*d*)	100 sand 60 ash	Drainings neutral, no ferrous sulphate.

Theoretically, 3 of ash should neutralize 9 of sand.
Actually, 3 of ash neutralized 5 of sand.

As a result of these experiments, and to obtain the full value of the calcium carbonate in the ash, it was suggested that the sand and ash be given as long a contact in water as possible, before the addition of fresh lime for the neutralization of the ferrous sulphate. By joining up at this stage with the current sand, any cyanide present would be converted into ferric-ferrocyanide, and no further cyanicide such as permanganate of potash would be required. It has been found more convenient, however, to handle the current sand separately.

The sand and ash mixture has been going underground, however, for about six months, and has proved very successful; much more successful than the laboratory work would have led one to expect. The mixture makes excellent filling, and I am told that the ash has a binding effect on the sand, causing it to set very hard.

Following are the details of last month's (October) sand-filling with this scheme:—

Old dump sand	22,000 tons
Ash from dump	2,200 ,,
Lime	13 ,,
Cost of lime	£32 10 0

From the utilitarian aspect we have achieved, in this instance, the objective to which we should all aspire, *i.e.*, the development of a new and more economical method of working, than the more obvious and costly one. From the aesthetic standpoint we can credit ourselves with the gradual removal of two of those unsightly blemishes with which we are all too familiar—sand dumps and ash dumps.

Before concluding, I wish to express my thanks to the Superintending Engineer and Manager of the East Rand Proprietary Mines, Limited, for their permission to publish these notes; also to Mr. E. H. Johnson for his helpful advice, and Mr. R. A. Cooper for assistance in carrying out the work.

Mr. John Watson *(Member of Council):* I would like to ask Mr. Toombs if the ash does any good beyond the alkaline earths, lime and magnesia, contained therein. He mentions, for example, one figure: 60 lb. of lime per ton of ash; that works out at 3%. For every 100 parts of ash handled only 3% of lime is obtained, does the remaining 97% play any useful part?

Mr. C. Toombs *(Member of Council):* It serves the purpose of filling and binding.

The President: I would like to ask the author of this paper, if he knows whether this has been carried out on any other mine than the one described?

Mr. Chris. Toombs: Not to my knowledge. The official in charge of this work is present, as a visitor. I do not know if he would like to say anything?

The President: We should be very pleased to hear anything he has to say on this.

Mr. J. H. Mark *(Visitor):* The combination of ash and sand on the Angelo Section of the East Rand Proprietary Mines has proved most satisfactory from a drainage point of view. The sand drains very much more quickly when mixed with the ash; settlement and subsequent reclamation of the pillars taking place much more quickly. These are the principal advantages from the practical point of view, that we have been able to discover so far.

The President: If there is no further discussion on this paper, I desire, in your name, to offer Mr. Toombs a hearty vote of thanks for bringing forward this eminently practical paper.

The vote was carried with applause.

FLOTATION CONCENTRATION EXPERIMENTS ON A TRANSVAAL GOLD ORE.

By F. Wartenweiler (Member of Council).

This paper is presented principally with the view of interesting metallurgical and mining members of our Society in the possibilities of the fascinating art of flotation of precious and useful minerals, and to encourage practical application of the art as a supplementary ore dressing step, particularly on refractory ores of districts outside the Witwatersrand area. Theories on the causes and action, and description of various machines and processes, have been prominent in the technical press, so that a general knowledge of the fundamentals of theory and practice can be assumed. Although the multiplication of machines and methods has been confusing, all aim at the performance of the same work, namely, the floating of the fine mineral particles and their temporary suspension in a froth.

The investigation had as its object the maximum recovery of gold from an arsenopyritic gold ore developed below the oxidized zone of the mine workings of a Barberton mine. Cyaniding this sulphide ore after grinding through 150 mesh gives a maximum extraction of 45%. This low extraction is increased from 3% to 5% by preliminary treatment with solutions of sodium carbonate or sodium hydrate for the dissolution of arsenical sulphide.

Recovery by amalgamation is negligible.

Sweet roasting followed by cyaniding, as determined by working scale tests on the mine, gave the following data:—

Crushed through 20 mesh.

Original raw ore, assay—14 dwt. = 100%

Gold loss by volatilization, 5%, leaving 95%

Cyanide charge of roasted ore ... ... 13·75 dwt.

Residue ... ... 1·80 ,,

Extraction ... ... 11·95 dwt. = 86·9%

Net extraction—86·9% of 95% ... ... = 82·5%

This comparatively low net extraction, combined as it would be with high operating costs, on account of local conditions, makes the assistance of roasting prohibitive.

Working trials with gravity concentration and cyanidation of the concentrate tail were made, a Deister table with dished deck being used. The total extraction was 70%, calling extraction the difference between the original ore assay and assay of total cyanide residue. The loss of gold in the treatment of the concentrate, by volatilization and in residue, was not determined at the time.

Flotation tests with various oils and in neutral, alkaline, and acid circuits, were carried out by the author at the Rand Mines Metallurgical Laboratory with a mechanical agitation type of machine, having a capacity of 500 gm. per test. By repeating under like conditions, sufficient weight of concentrate and tailing was obtained for any extraction tests. The small portion of coarse sulphides not floated was recovered by panning and added to the flotation concentrate. Unless the ore was ground extremely fine, flotation needed this supplementing by gravity concentration.

The best results, from a commercial and metallurgical point of view, were obtained in a slightly alkaline circuit. The particulars of a number of combined tests were :—

The ore which had been kept submerged, to prevent serious oxidation, was ground, in water, through 90 mesh. It was pulped in water in a ratio of 5 to 1 with wood creosote and paraffine oil. Sufficient lime in solution was added to bring alkalinity to 0·005 CaO.

After agitation in the machine for 15 minutes (withdrawing the froth concentrate with a skimming tool, as formed), the dark persistent froth of fine mineral floccules gradually changed to a froth of a lighter colour, and gangue composed of slaty and schistose material was floated. The machine was stopped when this stage was reached and the tailing discharged. The froth formed during the early operation of the test was clean mineral showing selective action by the oils used and a flocculation of the fines. Flotation and skimming of froth was continued until the froth forming showed no sulphide. This prolonged flotation contaminated the concentrate, and it was therefore subsequently cleaned and enriched by running through the machine separately. The products from this last operation were concentrate and middling. This procedure is considered sound and is established by modern practice; the middling usually being returned to the head of the roughing machine for re-concentration.

The proportion by weight and the distribution of gold in the different products were :—

Product.	Per cent. Weight.	Assay. Dwt. per Ton.	Value per Ton Original Ore. Dwt.	Per Cent. of Total Gold Value.
Concentrate ...	14·7	67·0	9·85	71·1
Middling	12·5	8·7	1·09	7·9
Tail	72·8	4 0	2·91	21·0
	100·0		13·85	100 0

The original value of the ore (constructed by calculation) is 13·85 dwt.

The middling and tailing were treated by direct cyaniding—air agitation. The concentrate was roasted, then amalgamated and cyanided. Extraction results were :—

Product and Assay.	Treatment.	Assay of Residue. Dwt.	Extraction. Per Cent.	Per Cent. Extraction of Total Value of Ore.
Roasted Concentrate 80·2 dwt.	Amalgamation and Cyaniding.	6·9	91·3	65·0
Middling, 8·7 dwt. ...	Cyaniding.	1·7	80·4	6·4
Tail, 4·0 dwt. ...	Cyaniding.	1·0	75·0	15·7
Total ...				87·1

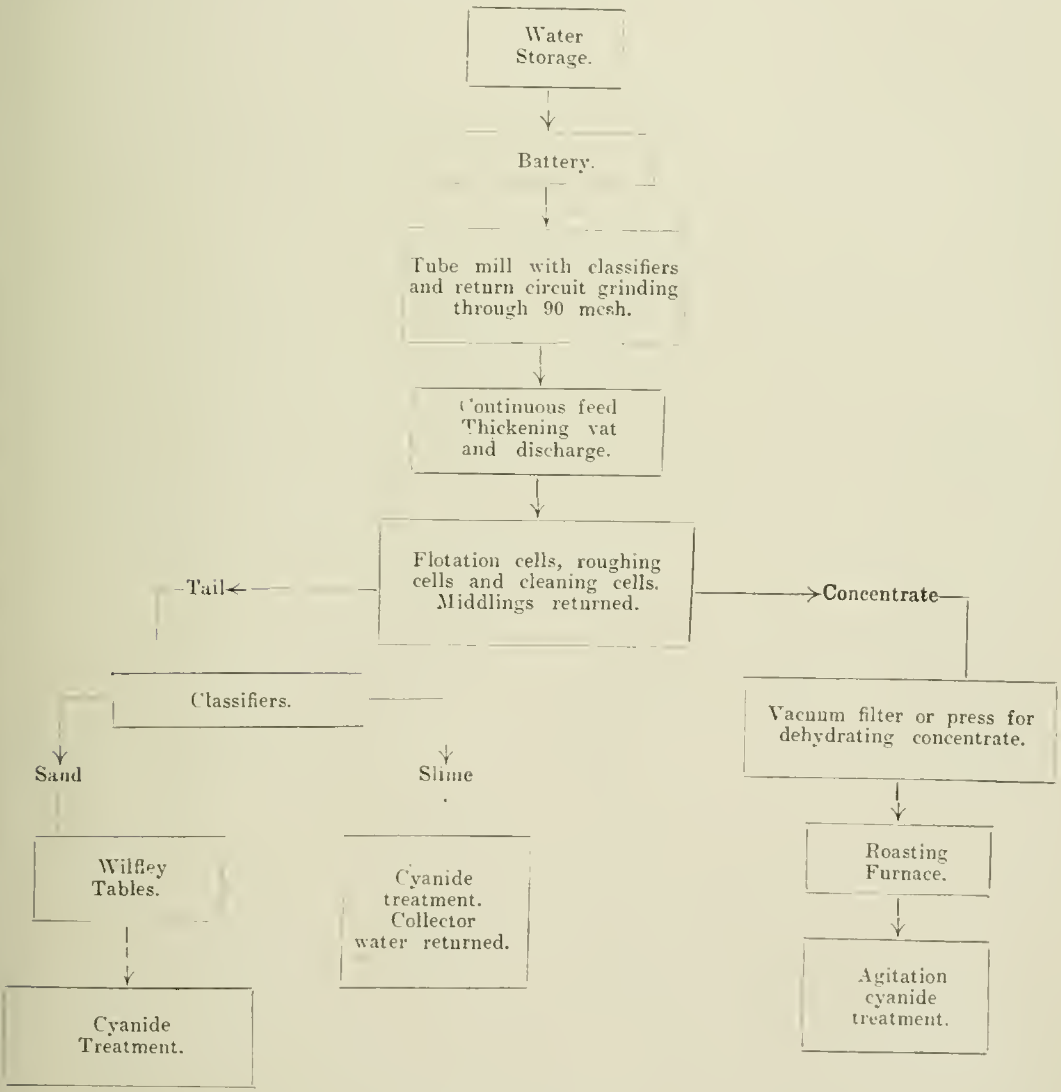
Calculated value of total residue, 1·78 dwt.

In cyaniding the concentrate, no attempt was made to treat this in the raw state, as earlier experience with raw sulphide ore had given results of a negative character. There was, for all practical purposes, no premature precipitation of gold by residual carbon from flotation oil ignited during roasting. This point was determined by post treatment of the cyanide residue with sodium sulphide.

The striking feature of the extraction tests, is the comparative ease of dissolving the gold in the middling and tailing, a feature which emphasizes the extent of the transference of the refractory minerals, by flotation, to the concentrate.

In a commercial application, it is advisable to assume a 5% loss of the gold contained in this particular arsenical concentrate, by volatilization, during roasting. This loss is 5% of 71·1%=3·55% of the original ore, reducing the total extraction to: 87·1% of 96·45%=84·05%.

A flow plan for a plant erected on the lines of treatment described is here suggested:—


Water Storage.
Battery.
Tube mill with classifiers and return circuit grinding through 90 mesh.
Continuous feed Thickening vat and discharge.
Flotation cells, roughing cells and cleaning cells. Middlings returned.
Tail
Concentrate
Classifiers.
Sand
Slime
Wilfley Tables.
Cyanide Treatment.
Cyanide treatment. Collector water returned.
Vacuum filter or press for dehydrating concentrate.
Roasting Furnace.
Agitation cyanide treatment.

Suggested Flow Sheet.

Turning again to details of the flotation experiments, it was interesting and important to observe that when working in a lime alkaline circuit, the nature of the froth, and consequently the concentrate, was sensitive according to the degree of alkalinity of the pulp. As it rose from 0·005% CaO, the froth bubbles became larger, more billowy and less selective, and at 0·010% CaO the surface of the frothing compartment became a mass of rapidly rising pulp coloured soap bubbles, making no distinction between mineral sulphides and gangue, and giving the impression to the observer of a complete flotation of all the pulp, provided agitation was continued.

In a neutral circuit, concentration was of the same effectiveness as in the presence of lime. Where the tailing has to be settled for cyanide treatment, it would be preferable to do so in a circuit slightly alkaline with calcium hydrate. Extra lime churned into the tailing seemed to assist slime settlement in the subsequent cyanide treatment by combining with and neutralizing any oil clinging to the colloidal particles.

The oils experimented with were:—Coal tar, wood tar, pine, eucalyptus, paraffine, turpentine, wood creosote, and combinations of these. Wood creosote proved to be a persistent frother of good carrying quality. When mixed with paraffine oil or common kerosene, the froth was selective; the contrary when it was omitted. Eucalyptus oil yielded a short selective froth, somewhat unstable, but as it did not float the heavier mineral to the same extent as creosote and paraffine oil, and on account of prevailing high local prices, exhaustive tests were postponed. It is reasonable to expect that the proper conditions for its effective use can be found, and that with a created demand, a supply could be procured from Transvaal plantations.

Prof. G. H. Stanley *(Past-President):* I should like to propose a very hearty vote of thanks to Mr. Wartenweiler for bringing this subject before us. It is a matter, of course, which excites a tremendous amount of attention in other parts of the world, not only with reference to the treatment of refractory gold ores, but the concentration treatment of all ores in which the values exist as sulphides.

While, undoubtedly, such work is useful, and will become increasingly useful from the practical standpoint, it is wonderful what a lot of scientific research work is yet required to enable us to understand why and how these particular sulphides will float when certain reagents are used, and why they will not float when others are used, and so on. At present, we have a list of something like 100 re-agents, and, in experimenting, one tries all these things one after the other; sometimes one gets results, but more often not. But, on what to base the experimental work from a scientific standpoint, nothing definite seems to be known at present. Still, as more and more experimental work is done, certain facts will become recognisable as the results are marshalled, and all details published on experimental work are useful.

The President: I should just like, in putting this vote of thanks, to endorse what Prof. Stanley has said with regard to practice in this case being in advance of science. I think it is one of those cases one meets with, where real scientific research has not yet come to the aid of the practical man, and the practical man has gone on without it. I have often been struck, more particularly when reading of the successful work which has been done, especially in Australia, in this field, that it has not been attempted here; and I think we are very fortunate in having a paper at last before this Society on this subject, because I feel there are many ores in this country, which possibly might be treated more successfully by this or other methods, than merely attempting to treat these ores by the ordinary methods in vogue on the Rand.

Mr. H. R. Adam *(Member of Council):* I should like to ask Mr. Wartenweiler what results were obtained

Mr. F. Wartenweiler *(Member of Council):* The results were practically the same. The advantage in past days was in favour of the alkaline, and for subsequent cyaniding.

Mr. H. A. White *(Vice-President):* There is one interesting point in connection with flotation I might point out. I think it is a fairly well known fact that one may take an ordinary needle, rub it between the fingers, make it slightly greasy, and it will float in water; but I do not know whether it is as well known that a Gillette Safety Razor blade will float just as easily.

The vote was then put and carried unanimously.

ORE TREATMENT AT THE FALCON MINE (RHODESIA).

By H. R. Adam, B.Sc. *(Member of Council)*

The Falcon Mine, situated at Umvuma, 160 miles from Bulawayo, has now been producing for over two years. Its monthly output being in the neighbourhood of 600,000 lb. blister copper, 3,000 oz. gold, and 6,000 oz. silver. It is the intention of this paper to give an outline of the milling and smelting processes, and to draw attention to a few specially interesting points in the practice.

*From 18,000 to 20,000 tons of ore are treated monthly, and of this quanity 14,000 to 15,000 tons consist of sulphide ore, containing 2½% copper as chalcopyrite, and 5 to 6 dwt. of gold per ton. The chalcopyrite is associated with iron pyrite and pyrrhotite. In addition, about 5,000 tons of oxidised ore from an "open cut" are treated, containing 0·3% copper and 4 dwt. gold per ton.

Sulphide Ore Scheme.—The fine and coarse ore separated by a grizzley at the main shaft are conveyed by mechanical haulage to the crusher station where the coarse is reduced to 2½ in. ring in three Hadfield jaw breakers. Four trommels with 1½ in. holes again separate into fine and coarse ore, the products passing by belt conveyors to the mill bins. From the coarse ore belt picked ore, amounting to 9% of the total is sorted for direct transport to the blast furnaces. This contains 5½% copper and 9 dwt. of gold per ton. The mill is equipped with 36 Nissen stamps, 26 of these being usually employed on sulphide ore, crushing 19 to 20 tons to ⅛ in. mesh in 24 hours. The stamp product passes directly over 12 "Record" vanners, the concentrate from these being elevated by two bucket elevators to launders conveying to two 30 ft. × 6 ft. concentrate storage vats. The tailing elevated by a 5 in. centrifugal pump passes to the classifying cones for two 18 ft. × 5 ft. 6 in. tube mills. The tube mill product passes over 10 more "Record" vanners, the tailing from which joined by the overflow of the tube mill cones run over blanket tables. From the blanket tables the tailing is lifted by a 6 in. centrifugal pump to cone classifiers, underflow from which is pumped back to the tube mills, overflow flowing to secondary cones preparatory to a partial unwatering for the flotation plant. The result of this "gravity" concentration is the recovery of 1,800 to 1,900 tons of concentrate per month, containing 5% copper and 19 to 20 dwt. gold per ton.

The underflow from the secondary classifiers goes to a sump, the overflow to three 30 ft. × 10 ft. Dorr thickeners. Thickened sand and slime with water in the proportion of 3½ to 1 of solids is then pumped to a steady head box, the flotation oil being added to the pump to ensure thorough mixing. Before entering the first flotation compartment or cell a sample of the feed is automatically cut out. The flotation plant is of the minerals separation type, and consists of nine compartments with agitators revolving at 250 r.p.m., producing a froth in the spitzkastens about 15 in. deep. This froth has a copper content ranging from 13 or 14% in the first compartment to 3% or 4% in the last, so that the froth or "middling" from the last three compartments is returned to the original feed. From 10,000 to 11,000 tons of tailing are treated every month, the feed values being 1·8% copper and 2·3 dwt. per ton gold; 2,000 tons of concentrate are recovered, containing 8% to 9% copper and 5 dwt. per ton gold by the minerals separation unit itself, recovery being about 86% for the copper and 43% for the gold.

The flotation concentrate gravitates to four 30 ft. × 6 ft. collector vats, where the coarser material settles. The fine concentrate in suspension is run to a 25 ft. × 8 ft. agitator, and thence to two filter presses of the Dehne pattern. The coarser settled concentrate is shovelled out at bottom discharge doors, stacked on the surface to dry and then trucked to the smelting plant. The tailing from the flotation plant is automatically sampled before passing to fine collecting vats where slime is separated for transport to the slime dam, the sand being hauled to the dump.

Oxidised Ore.—10 stamps are usually employed on oxidised ore crushing 25 tons per 24 hours to ⅛ in. mesh. The product is passed over four tables of the first vanner set, the tailing from these re-ground in a third 18 ft. tube mill, and the product passed over three of the second vanner set and thence over blanket tables. The result is the recovery of 300 tons concentrate monthly, containing 1·5% copper and 47 dwt. per ton of gold, which is sent to the sintering plant. About 250 tons picked oxidised ore are used up every month in lining the converters.

---

*By courtesy of the Goldfields Rhodesian Development Co., Ltd., approximate figures are given.

The mill concentration plant recovers about 60% of the gold and 20% of the copper while the flotation plant recovers 20% of the gold and 70% of the copper, a total extraction of 80% of the gold and 90% of the copper by concentration.

About 3,500 tons of sinter, containing 14 dwt. per ton gold and 3·2% copper are produced monthly. Very little of the flotation concentrate is sintered, as its fineness and sticky nature make it unsuitable for the process.

The two blast furnaces (one in use at a time) are each 120 in. long and 46 in. in width, at the tuyere level each furnace taking 300 tons charge in 24 hours with an output of 36 tons of matte in that time. The charges consist of sinter, picked ore, flotation concentrate and old converter linings and customs ore, with additional flux in the form of limestone and blast furnace returns. The fuel is a mixture of coke and coal. Experiments at the mine proved that up to 50% of coal could be used safely and with considerable resulting economy. The air blast at about 20 oz. pressure, when smelting is in progress, is derived from two turbo blowers, with a capacity of 12,500 cub. ft. of free air per minute to 30 to 50 oz. per square inch.

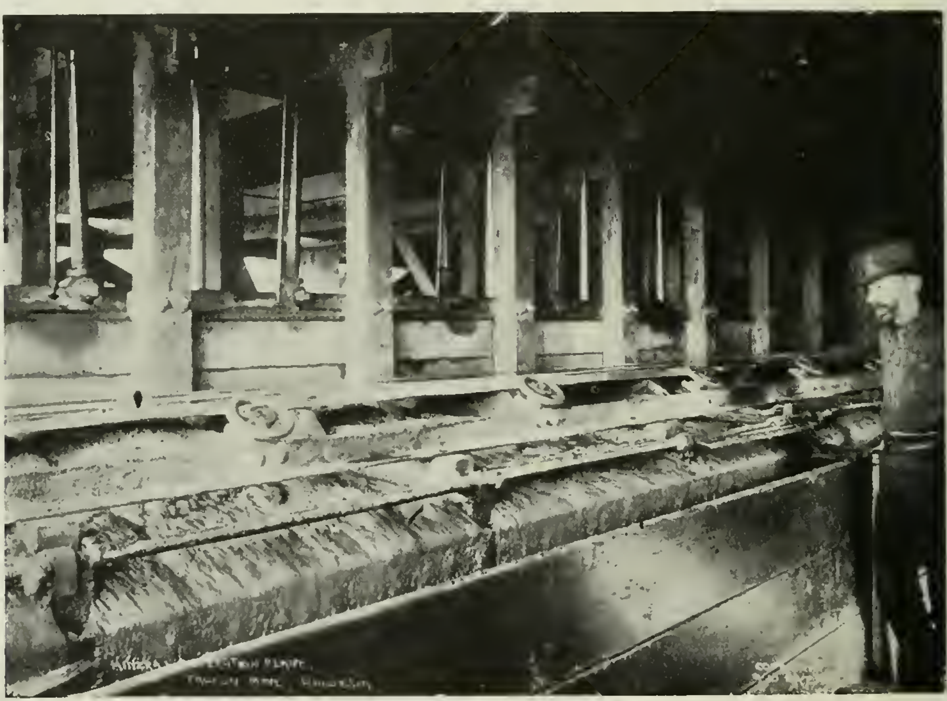


Fig. I.—Flotation Plant.

Smelting Plant.—The mill concentrate from the collector vats is conveyed by trucks to the sintering plant, where twelve blast roasting pots are in operation. These are hemispherical in shape, 8 ft. in diameter and 4 ft. in height. They are situated on a platform 12 ft. above ground level for convenience in discharging and breaking up of the sintered product. They have a capacity of 8 tons of charge each, and a charge requires about 8 hours' treatment. The charges are made up of:

Mill Concentrate	60% to 65%
Granulated Converter Slag ...	15% to 20%
Fine Ironstone Flux ...	10%
Flue Dust	10%

The matte, containing 32% to 35% copper, runs from the forehearths to 8 ton capacity matte ladles, which convey it by electric crane to the converters. One converter is kept in operation, and one as a standby, while the shells of four others are being re-lined. They are of the upright type, of 15 tons copper capacity per 24 hours. They do four "blows" per day, consuming 36 tons matte and producing 12 tons copper. The latter is poured into steel ingot moulds, conveyed on carriages, producing ingots of 360 lb. weight, containing gold and silver to the value of [*]10 and 20 oz. per ton respectively. Smelting recovery is 96% for the gold and 90% for the copper.

From the foregoing it will be seen that the plan of treatment is on the standard lines adopted at many copper mines in the United States, Australia and elsewhere. In the Transvaal, however, we have little opportunity of seeing similar processes and it may, therefore, be useful to remark on one or two points in the practice.

Dealing first with the "gravity" concentration plant it will be noticed that a large proportion of concentrate is obtained after comparatively coarse crushing by stamps. This product is particularly suited for part of the sintering charge.[1]

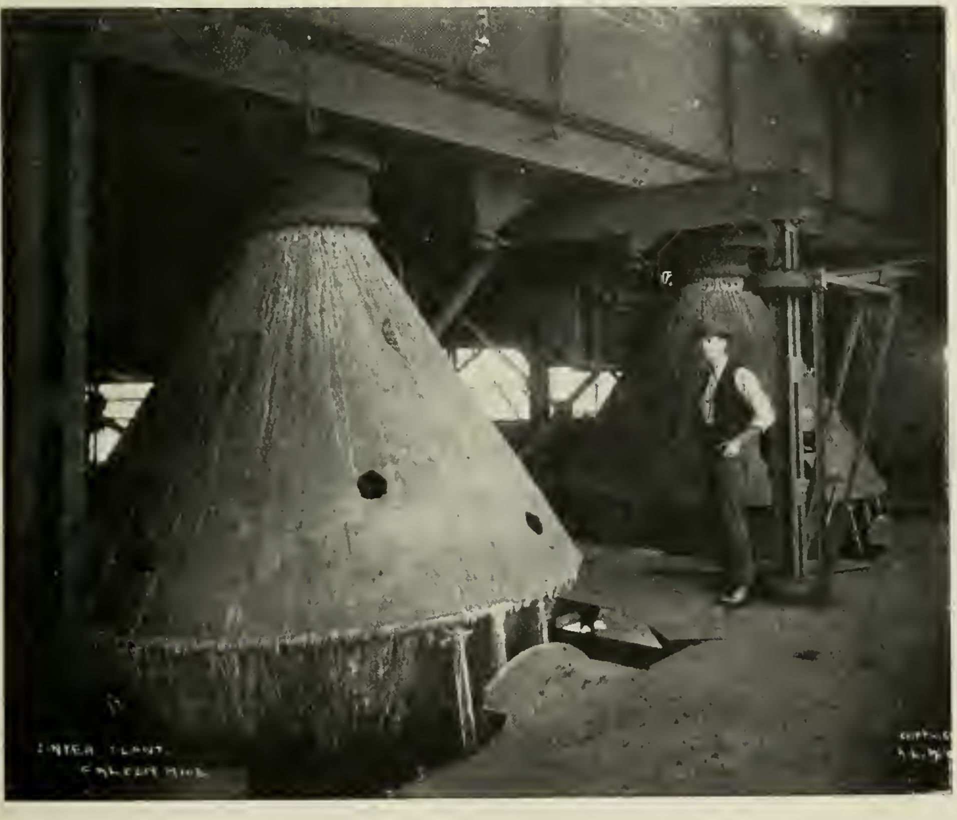


FIG. II.—Sintering Plant.

Efficient equipment is provided for the recovery of flue dust from the sintering pots, blast furnaces and converters: the flues from these lead to the main flue, containing two settling chambers from which the flue extends about 900 ft. up the side of a hill to the brick stack, 150 ft. high by 8 ft. diameter. The settling chambers are cleaned out every month, and the main flue once a year.

The Falcon Mine equipment contains the first large scale flotation plant in South Africa, and it is of great interest to study the results by it and to see how its introduction affects other parts of the treatment. Obviously, in the case of the Falcon tailing it is not an efficient gold saver, only a little over 40% of the tailing gold being recovered. No doubt, by altering the details of the flotation scheme, *e.g.*, quantity and nature of oil, introduction of heating and acid, etc., different results might be obtained, but whether a greater gold saving would more than counterbalance the increased treatment cost is doubtful since at present the flotation unit is run very cheaply without heating or addition of acid. Also a greater gold recovery may mean a greater percentage of quartz gangue in the froth which already carries about 40% "insoluble matter." The flotation results indicate that the gold is not closely associated with the copper sulphide, and since pyrrhotite should also be chiefly in the froth it may be assumed that the gold bearing quartz is fairly well separated from the sulphides by the fine crushing necessary for flotation. In this connection it is interesting to note that at Goldfields, Nevada,[2] where copper bearing gold ores are being worked, slime concentrating tables are sometimes installed after the flotation plant.

---

[*] The blister is shipped to New York, then refined, and the copper sold as electrolytic.

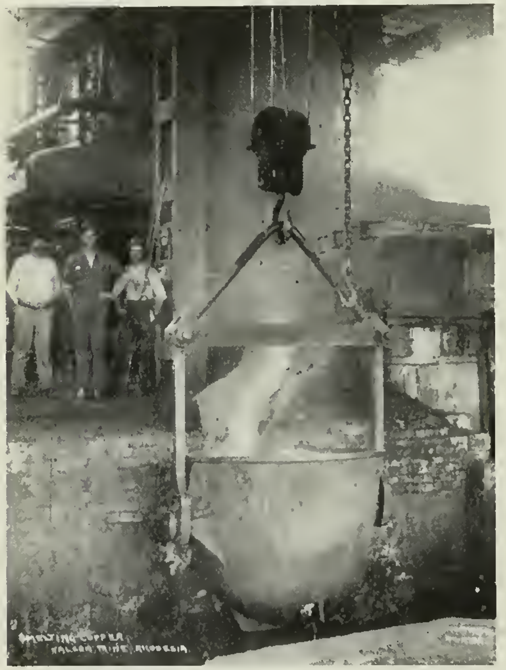


Fig. 11.—Tapping Matte from Blast Furnace.

It is intended at the mine to introduce a "cleaner" unit of six compartments and an Oliver filter for the treble purpose of improving the grade of the flotation concentrate, decreasing its bulk and facilitating handling. The last point is important; the handling of flotation concentrate has proved to be quite a difficult matter in practice, and that this has been the experience elsewhere is seen by the amount of work being done on the subject in America and Australia.[3] It is a problem similar to but of greater complexity than the handling of colloidal slime. The addition of "flocculating" agents might be successful on an experimental scale, but in view of the return of water and oil to the feed, their accumulation in solution might have unlooked-for effects in practice.

The effect of the production of large quantities of flotation concentrate on smelting practice is also interesting, since like other fine concentrate it is more suited to reverberatory furnace smelting than for blast furnaces. Developments in sintering or in other allied processes preparatory to blast furnace smelting may, however, follow.

I have to record my thanks to the Goldfields Development Company of Rhodesia, to Mr. H. T. Brett, General Manager, who has kindly read over and amended these notes, and to Messrs. Tipping, Jeffries and Turner, of the milling, flotation and smelting departments respectively, for the kindly way in which information was given during a short visit to the mine.

References.

[1]. Pot-roasting of copper ores.—Radcliff, *Australian Mining Standard*, Dec. 2nd, 1908.

[2]. A. H. Martin.—*Mining and Engineering World*, June 3rd, 1916.

[3]. Metallurgical Disposal of Flotation Concentrate. —R. J. Anderson, *Mining and Engineering World*, July 8th, 1916.

The President: We are very much indebted to the author for this paper, which is the result of a holiday jaunt in Rhodesia during the last vacation, a practice which might be commended to our members. We are also grateful to Mr. Adam, for giving us in detail the work which is being done at this mine, which is so extremely different from any experiences we have here. There is one thing in the paper which struck me as being very wrong, namely, that the copper was shipped to New York to be refined. The copper refining process is one of the simpler processes of metallurgy, and it is a reflection on us in this country, that we cannot carry it out here. I do not think it would want very much research to set up a copper refining plant here. We imported into this country in 1913 £13,000 sterling worth of copper-bar, ingot rod and sheet, and we have shipped out of it each year, during the last ten years, about half a million pounds sterling worth of copper ore and matte. Some of the richest copper ores, I think, in the world are to be found in this country. Hence, a copper refining plant is one of the most urgent necessities that we have. With these few remarks, I should like to offer your thanks to Mr. Adam for this paper, which has been so extraordinarily interesting.

Dr. W. A. Caldecott *(Past-President)*: With regard to the amount of copper shipped from this country, if one includes the great copper fields of Katanga, in the Belgian Congo, I understand that there is being shipped at the present time through Beira, crude metallic copper to the value of some three million pounds per annum. Apart from electrolytic refining, there seems no reason why much of this could not be converted into wire in this country.

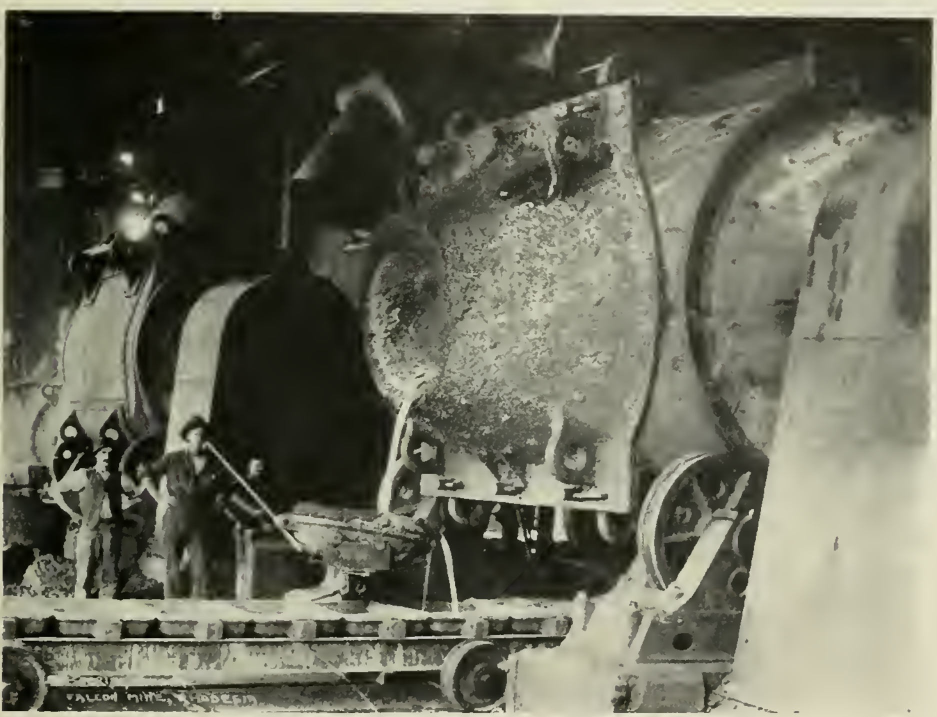


Fig. IV.—Pouring Blister Copper.

Prof. G. H. Stanley *(Past-President)*: I should like to ask the President why he considers it wrong to ship three million pounds of copper, because we cannot use anything like that amount of copper in this country? Apart from the question of whether all or most of this copper needs electro-refining—such treatment here or oversea is purely an economic matter, and a question of cost and market.

The President: I understand from Dr. Caldecott's remarks that this is not pure copper ready to be made up into electric wire, and sheets, and so on, but that it is copper matte.

Dr. W. A. Caldecott *(Past-President)*: I think it is a crude form of copper, which requires subsequent refining. With reference to what Prof. Stanley said, I very much doubt whether the £13,000 worth, to which the President referred, includes copper wire, etc., imported for electrical apparatus.

The President: The statement I made was £13,000 sterling copper bar, ingot or plate. If electrical requirements are included, I think it would reach a figure of something like a quarter-of-a-million. There is no reason, as I said before, why we should not refine some of this copper, at any rate, for our own wants, and, if there is anything over, we can export it.

Mr. J. A. Woodburn *(Associate)*: I have listened with very great pleasure to the paper by Mr. Adam to-night, and probably will have something more to say once I have read it through. It goes into the treatment of copper ore further than anything that has been done so far in the Transvaal, and as the ore contains gold and silver, it necessitates electrolytic refining. In the Northern Transvaal the ore does not contain any appreciable quantity of the precious metals, and thus the matte can be refined by the ordinary smelting methods.

The whole question of copper production is one which ought to be gone into very carefully, because if you include the Tanganyika production in the South African output, there is going to be a large export of copper in the near future.

If copper refining were adopted, South Africa could not utilise all the pure copper and would have to export it. It does not seem to be outside the bounds of possibility to get a market for copper equal with other countries, and in that way, not only create further industries in this country, but be able to export pure copper for manufacturing purposes in other countries. That, I think, must be considered in connection with any question of copper refining, because at present, and for some time to come, the total consumption in South Africa will not come to anything like the production, when Tanganyika has reached its full output.

I understand the bulk of the Tanganyika ores are not so suitable for smelting, and for some of the ores the wet method may have to be adopted. The whole question is being carefully considered, and as soon as a definite method of treatment has been agreed upon, the total output should be greatly increased.

Mr. H. A. White *(Vice-President)*: With reference to what has just been said, I should like to say, that a few months ago there were some gentlemen from the district of Tanganyika looking round the Rand to see, if any of the ideas in vogue here could be used in Tanganyika. The real difficulty about this shipping of copper to New York seems to have been overlooked.

The real point about it is this: at the present time our shipping facilities are being cut down, and we are sending from this country metal to New York and re-importing that to England. There seems to be very little, to my mind, to prevent our sending that ore, or that ore product, direct to England.

Mr. H. R. Adam *(Member of Council)*: In fairness to the Rhodesian Company, I may say they did their best to sell their copper to Britain, but the penalties for impurities were very much more severe with British buyers than with the American, that is, before the war broke out.

CONCRETE SHAFT EQUIPMENT AT THE BANTJES CONSOLIDATED MINES.

By W. W. Lawrie and G. Hildick Smith *(Members of Council).*

(Printed in Journal, April, 1916.)

REPLY TO DISCUSSION.

Mr. G. Hildick Smith *(Vice-President)*: Unfortunately, there is practically no discussion on this paper to reply to. As Mr. Lawrie is still away on leave I am responsible for the following remarks: It is unfortunate that there has not been any real discussion on this question, because evidently this paper has brought this form of shaft equipment to the notice of men on the Rand, with whom lies the decision as to the method of shaft equipment on the mines. I have had at the mine, presumably, as a result of this paper, several managers, underground managers and mine captains, who came to further investigate the possibilities of concrete equipment in shafts. This goes to prove that after all some of our papers evidently are of practical use, so that Mr. Weston was right when he said that the practice might be introduced into quite a number of other mines, and I believe that since this paper has been written it is actually being introduced into other mines.

The remarks of Mr. Foster Bain are very interesting, and it is unfortunate that he did not give us more detailed descriptions of what is the practice at the Creighton Mine of the Canadian Copper Company. With regard to their method of equipping he says, in respect to the tieing in of rails, it was not felt safe to place the rails directly on the concrete stringers, steel girders of a special design being set in the concrete as sleepers. It would be interesting to know in this case what happens when a skip becomes derailed, much more damage would then be done than is the case with skip derailments in a shaft with our type of equipment where when the skip becomes derailed, as Mr. Price mentioned, very little harm is done. It would also be most interesting to know how, with a dip of 55 degrees, the rails are anchored to the steel sleepers.

THE ENCOURAGEMENT OF FIRST AID WORK ON THE MINES: SOME SUGGESTIONS BASED ON CROWN MINES EXPERIENCE.

By A. J. Brett.

(Printed in Journal, June, 1916.)

DISCUSSION.

Mr. G. Hildick Smith *(Vice-President)*: Mr. Brett's practical paper on First Aid work has been read at a very opportune time, as the local "Safety First" movement requires a First Aid movement in conjunction with it before it can be said that we are doing everything possible to save life on the mines of the Rand. The importance of First Aid work on the mines is fully recognised by the Directors of the Mining Groups, as is shown by the fact that the Chamber of Mines has lately agreed to the following suggestions of the Prevention of Accidents' Committee

A. The class fees of any man who attends more than ninety per cent. of the classes forming a course of First Aid Instructions, as offered by the South African Red Cross Society, be refunded.

B. A bonus of, say, a guinea be paid to every man who obtains the advanced certificate or medallion of the S.A. Red Cross Society.

Note.—It is estimated that the cost of the foregoing two suggestions may approximate to £1,800 per annum for the Rand. Recommendations A and B do not apply to officials who are compelled by the Regulations to hold certificates.

C. A monthly bonus be paid to a competent certificated man at each shaft (such as the Mine Captain's clerk), or, where two shafts are close together, to one man for the two shafts. This man to be designated Ambulance Officer, and to be charged with the duty of looking after all First Aid equipment, supervising the rendering of First Aid to all serious cases and, generally, keeping in touch with First Aid work on his mine, or section of his mine, as the case may be. He should be in possession of a roll of all First Aid men on his section and, further, he should be in possession of a certificate not more than three years old.

D. Prizes shall be provided, to be competed for by the several teams from each mine, say, an underground team against a surface team, or section against section.

E. The necessary expenditure for the purchase of First Aid class apparatus should be authorised.

In order to make the First Aid movement a real success the employees of the mines must pull their weight in the matter. At present they are not, as a whole, sufficiently interested in First Aid work. In order to improve matters in this respect the Crown Mines have had to offer their employees inducements to encourage them to take an interest in First Aid. The system adopted by the Crown Mines leaves little room for improvement, and is excellent as far as it goes. The question is, does the scheme go far enough in inducing employees to interest themselves in First Aid and assist in creating a really efficient local First Aid force? The ideal result of the First Aid movement would be that all mine employees should hold First Aid certificates, and all be kept in practice at First Aid work; as to how near it is possible or practicable to approach such an ideal remains to be proved. The amount of progress and improvement in First Aid work on the mines unfortunately depends on how much the employers are willing to spend to encourage their workmen in this work. It will cost much more than £1,800 per annum, as estimated by the Prevention of Accidents' Committee, to make a really efficient First Aid force on the Rand, as, in addition, to the inducements offered by the Crown Mines some such further inducement as the following would be necessary in order that, perhaps, half the white workers on the mines would eventually become efficient in First Aid work.

1. Preference to be given to men applying for work who hold a First Aid certificate.
2. Time off to be allowed workmen to attend First Aid classes.
3. A slightly higher rate of pay to be paid to men holding First Aid certificates less than three years old as compared with men on the same class of work who have older certificates or no certificate at all.
4. In inter-mine ambulance competitions a bonus to be paid to all men holding First Aid certificates on that mine which has the highest percentage of its

employees with First Aid certificates.

It has only to be decided as to what we are out for in regard to First Aid work, or, in other words, as to what amount the mines are willing to expend to obtain good results in the saving of life and prevention of suffering, as the limit of expenditure, under existing conditions, will limit the efficiency and strength of the First Aid force on the mines.

The President: I am very glad to see here this evening one of our newest members—Dr. Orenstein, whom I would ask to say a few words on the subject of mine ambulance work, because I know he has been interested in this subject.

Dr. A. J. Orenstein *(Member):* I really think it is very encouraging that this Society has found time to allow Mr. Brett to read a paper on this subject, as it shows that First Aid is receiving the attention, which it so richly deserves.

A mortality of about 3½ to 4 per thousand employees among the whites and natives—it runs practically parallel—is caused by accidents, and, in addition to this, a total of one half of the morbidity among the natives is caused by accidents; this amounts to thousands and thousands of days of work lost per annum. I think that of these accidents among natives 60% are minor things, such as scratches, and these cause a great deal of loss to the mines. From an economic point of view, it is quite obvious to all of you, it does not matter whether a man stays in hospital for three weeks with an ulcer on his leg—there are many natives staying in the hospitals on the mines now for weeks at a time because of minor affections to the legs—or because of a broken bone. Of course, prevention of these accidents by such means as boots and leggings should come in; and, after all, I think this would pay if it were efficiently carried out. But it would reduce the loss of time among natives, if every native could feel that he could go to his immediate "baas" and get some sort of treatment for his wound. Such treatment would considerably reduce the time spent in hospitals.

But what particularly strikes me is this: Granted that while it is desirable to have, if possible, every white man underground in possession of a First Aid certificate—(remembering that there are about 10 natives to each white man, and that we cannot teach the natives First Aid), it is improbable, in spite of the encouragement recently held out by the Groups, that we shall get this 100% efficiency; but supposing, say, 10,000, or even 5,000 want to take up First Aid work—how are we going to teach them, and having put them through a more or less perfunctory course of instruction, how many of these would forget all about it unless they repeat their course? In other words, having made arrangements to teach as large a number of men as possible, we must also encourage these men to repeat their course at intervals. Now, supposing we get 10,000 or 5,000 applications for men on the Reef to be taught First Aid, who is going to do the teaching?

In Pennsylvania, the bulk of the instruction to coal miners is done, not by medical men, but by laymen specially trained in First Aid work to teach the miners. I think we might well adopt this course. The number of medical men on the mines here, who give their full time to mine work, is very small; their time is very fully occupied. Many of them, although they know medicine, are not perhaps, quite prepared to teach First Aid, because they do not take any special interest in the matter, or are not naturally good teachers. The detailed knowledge of a subject does not necessarily make one a good teacher. Would it not be worth while considering whether we could not, by some means, get laymen, hospital superintendents, or miners, or office staff—I do not care who they are—specially train these by a few selected teachers, and thus form a corps of instructors who could teach the elements of First Aid to miners in a way that would interest them more than instruction by a medical lecturer, who is apt to slip off into technicalities?

I know complaints exist amongst miners that classes in First Aid, as carried out today, are occasionally given to them in a way which is, using a popular expression, above their heads.

The opportunity for a new start now exists, and, I for one, feel that a start should be made along the lines of selecting some of the best intsructors among medical men, and organising special classes for men who would be prepared to go on and spread First Aid work among the miners. That is an idea I would like to put before this Society and the S.A. Red Cross for their careful consideration. I know a great many difficulties arise. I know it is, perhaps, a little difficult to carry a thing of this sort into effect here, because of professional considerations, but I think these difficulties are not insurmountable, and I think the end in view certainly justifies most careful consideration of this point. We must make the First Aid classes popular and attractive in order to get as many people as we can, and we must organise the course on much simpler and more practical lines. I, myself, do not care a hang if a miner knows or not whether there are one or two bones in the forearm; but I do care that he should know what to do when the two bones, or the one bone, happen to be smashed, and that he should know how to put a board across the broken part and tie it up. We do not want our miners to be experts in anatomy, or know how to diagnose and treat poisoning by belladonna, or aconite, or other drugs—drugs which are merely names to them, and not obtainable on mines. But we do want them to know how to stop haemorrhage, and how to take a man out of a mine without causing him unnecessary pain, and how to fix up a fracture, which is, after all, a very commonsense thing, so as to prevent further damage than that which has been done in the accident.

The President: With your permission, I should like to interject into this discussion once more on two points raised by the last speaker. The first is, I cannot believe he is sincere when he says a kafir cannot be taught First Aid, because, I believe a kafir can be taught First Aid, and, as a matter of fact, the actual proposal has been made to me, as Chairman of the Red Cross Society, that some kafirs should be taught First Aid.

Now, with regard to the second point, that is, teaching by medical men and teaching by laymen, or demonstrators, I have a very great deal of sympathy indeed, from a practical point of view, with what Dr. Orenstein has said. The question that has been raised, as to whether the work should not be done by trained laymen, is one which, I may say, is receiving consideration at present, and I can assure Dr. Orenstein it will receive every possible consideration that the Council of the Red Cross Society can give it, and I sincerely hope that something will eventuate which will be of very great practical use to the men whom we wish to assist, namely, the miners themselves.

Mr. T. P. Waites *(Member):* With regard to this matter of First Aid, I should like to say that I agree *in toto* with what Dr. Orenstein has put before us. I would like to ask also, seeing there are some strong representatives of the Red Cross Society here, whether they have considered the mentality of the men in connection with the manual, which the men have had to take, whether they understood it or not.

With regard to the lectures and the men not attending, I know absolutely that the lecturer's time is considered first and the miners' not. Also, I am quite satisfied that, if we had lay-lecturers, instead of medical men as lecturers, the matter could be put before the men in a form which they could understand. There are far too many technical words. An advance has been made through a small pamphlet, or Manual issued by the Rand Mutual Assurance Company. This was distributed throughout the mines quite free to underground workers, and, at a charge of 6d. to the surface men, and judging by the way it was given out, and taken up, I hope that it has been very generally read, and that the men are wiser. But so many of these men, after they have done their eight hours or more underground, do not feel disposed to go in for what to them is intellectual work. I think I can put myself in the position of an average man; when I have done my eight hours' shift underground, I do not feel disposed to do any heavy reading. How much more so would it be for those whom I might call semi-literate, and who do not do any reading at all except certain portions of the daily newspaper. Before you can get them to grasp this matter of First Aid—I am talking now of the theory of it—these lectures will have to be cut down and, at the same time, will have to be made much more simple, much more interesting, and much more acceptable. A great many of the miners are like other people; they are very willing to do these things when they are compelled. I am perfectly satisfied that the inducement of prizes has no effect on them at all. But, with the large number of accidents that are occurring daily in our mines, I quite agree with a recent correspondence, which said that each man ought to be compelled to study for his certificate in First Aid concurrently with his blasting certificate. I also think, considering the large percentage of Dutchmen who are working underground, that a translation of this Manual into the Taal would reach a considerable percentage of men which the present one does not reach. And, I think also, that it is rather asking too much that the officials of the mine should have this work thrown on them. From what I see, the shift-boss has quite enough to do without having to interest men in matters of First Aid. The matter will have to be gone into by the Red Cross Society, and there ought to be some orgaised system of lecturing, for preference, those lecturers should be laymen who understand the miners and the mentality of the men to whom they are giving forth of their knowledge. It is no use saying: "This is good enough," and "These are our works and our manuals"; unless you go down and see who these men are to whom you are giving this food, for, what is one man's meat is another man's poison, in this as in other things. Further, it is only a cram as it stands at present. I will again throw it out that the plainest food be given to these miners; no intellectual men would undertake the work; but, I think the First Aid movement that this Society has taken up, especially this paper, on the encouragement of it—by Mr. Brett, is aimed directly at encouraging the practice, and I think practice ought to be a little more considered. The lectures, as I have experienced them, are not intelligible to the ordinary miner. The practical part given by a layman, or superintendent of the native hospital, is understood and interesting, and the men also, showed that they were efficient in practice, and many of them who were almost ignorant of the theory, were efficient in the practical part.

The President: I should like to inform the last speaker that the Manual is being translated into the Taal, and will be issued shortly by the Rand Mutual Society..

Mr. T. P. Waites: May I ask if you can tell us what percentage of underground workers has taken the Red Cross Society's certificate, or its equivalent?

The President: The Red Cross Society has issued about 1,750 certificates.

Mr. T. P. Waites: To underground workers?

The President: They do not give us that information; and we do not ask for it. So I am afraid I cannot answer that question.

THE MANGANESE SILVER PROBLEM

By Walter Neal *(Corresponding Member of Council).*

(Printed in Journal, September, 1916.)

Dr. W. A. Caldecott *(Past-President):* I think we are to be congratulated on receiving this paper from Mr. Walter Neal, who is not only one of our oldest Corresponding Members of Council, but has always taken a keen and friendly interest in the affairs of our Society. As pointed out some years ago,* the problem has long been known to exist in Mexico, but I think it is only quite recently that any clear light has been thrown on its cause. Some time ago, on considering the point, I thought that possibly the cause might have been the oxidation of metallic silver by manganese oxide into silver oxide which combined with the silica present to form silver silicate. Mr. White assures me, however, in view of the work which he has recently carried out that this hypothesis is untenable, mainly, I understand, on account of the ready solubility of the silver in the ore in ammonia, which he thinks would not take place if there were a considerable quantity of silver silicate existing. Possibly he might throw a little more light on that point.

Mr. H. A. White *(Vice-President):* I would just briefly remark, although Dr. Caldecott was not available at the time, I was fully aware of his views on the subject, and I bore in mind in the investigation I was making, the possibility of the existence of silver silicate, but could find no reasonable confirmation, from the experiments reported.

THE HARDENING AND ANNEALING OF METALS.

By Thomas Turner, M.Sc., Professor,
University of Birmingham.
(Hon. Member.)

The President: Prof. Stanley, as promised at the last meeting, will now demonstrate the scleroscope and its use.

Prof. G. H. Stanley *(Past-President):* In connection with Prof. Turner's paper it was stated by the President at the last meeting that some account of the methods is use for determining hardness would be acceptable to the members, though, I think, we must assume that I can present nothing which will be of any novelty to the author.

The methods of present day importance are those I mentioned previously, *i.e.*, Brinell's and Shore's scleroscope. The former depends on pressing a steel ball of known diameter into the metal under exami-

---

*See this *Journal*, Vol. VIII., Jan. 1908, page 204.

nation, by means of a known pressure. Usually a standard size ball of 10 mm. or 5 mm. diameter is used under a standard pressure of 3,000 kg., which is maintained for 15 seconds for iron or steel, and 30 seconds for softer metals. When the pressure is released, a small depression remains on the surface of the specimen, and by dividing the total pressure on the ball—in Kg—by the spherical area of the depression, a "hardness number" is obtained. If D=diameter of depression, measured under a microscope, r=radius of ball, K=total pressure in kilograms, and H the "hardness number."

$$H = \frac{K}{2\pi r\left(r - \sqrt{r^2 - \frac{D^2}{4}}\right)}$$

The lantern slide exhibited* illustrates such a machine.

This can be regarded as the standard method, because the values obtained are generally considered to be the most reliable yielded by any of the methods proposed, but obviously this instrument has limitations in its applicability to engineering or metallurgical practice.

To render the results more easily obtainable, and without such careful measurement or calculation, Martens devised the form shown in the next slide†, in which an indication of the depth of the depression produced is given by means of a thread of mercury in a capillary tube: being magnified by causing a plunger to pass into a mercury reservoir to the same depth as the depression, and thus displace a quantity of mercury into the capillary tube. The other disadvantages remain, and recently a portable form of the apparatus has been described.‡ Another, which weighs less than 7 lb., is described in the same journal. In this a ball is pressed between the metal under examination and a bar of steel of standard hardness. The actual pressure is in this case immaterial, and the relative hardness varies as the square of the diameters of the indentations and, is therefore, rapidly ascertained.

Sometimes a cone is preferred to a ball, and was formerly in use in the same manner.

For workshop use, the Shore scleroscope has many advantages which, for this purpose, more than compensate for its somewhat less accurate indications, and it can be used for metal of any hardness, a point of some importance, since in the Brinell method an extremely hard steel may damage the ball itself.

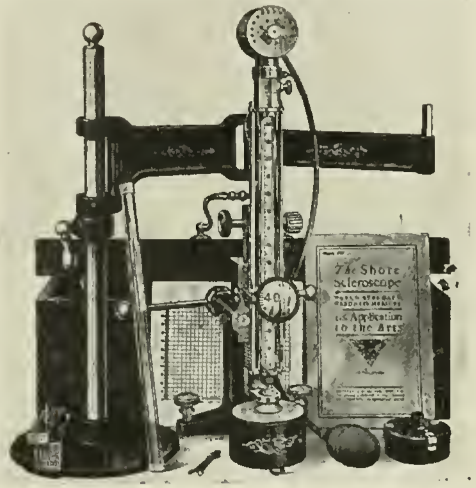


Fig. I.—The Shore Scleroscope Testing Apparatus.

The slides exhibited* illustrate the apparatus and the method of employment.

It depends on the measurement of the "rebound" of a "hammer" which is dropped upon the smooth surface of the metal under examination from a standard height. The "hammer" usually consists of a small steel cylinder terminating in a cone, the point of which is provided with a rounded diamond tip, 0·02 in. diameter. The fall of this on to quenched steel "100 hard" develops a pressure of about 500,000 lb. per sq. in. The slides show the instrument in its highest state of perfection, but quite useful work can be done with the very simple form which I have exhibited, and which was made in our engineering workshop. As may be seen, it is merely a glass tube, rather less than 1 cm. in diameter, graduated to enable the height of rebound of the little ball or hammer which is used to be read off. The hammer is made of hardened tungsten steel, and has no diamond point!

It is important that the specimens have a smooth, but not polished surface, and that the surface is horizontal and the glass tube perpendicular. Also that the metal is very rigidly supported. It is obviously not a very accurate instrument, and the average of two or three observations should be taken.

---

*Harbord's "Steel," p. 320.

† Rosenhain's "Physical Metallurgy," p. 220.

‡ *Metallurgical and Chemical Engineering*, May 15, 1916, p. 612.

*Coat's Machine Tool Co., New York

Shore claims that the "ball," or Brinell, test result is most closely connected with the *ultimate* hardness and, therefore, with the *ultimate* strength, and that the true or normal hardness is more intimately related to the *elastic limit*.

My colleague, Mr. Alexander, who was responsible for the construction of this simple apparatus, contributes the following notes from the engineering standpoint.

Mr. W. Alexander *(Visitor)* (contributed): No generally accepted definition of hardness has been enunciated. Two of the well known methods for determining hardness, mentioned in the paper, are those of Brinell and Shore. The Brinell hardness is really the resistance of a material per unit area to impenetration by a ball: the scleroscope hardness of Shore is 150 multiplied by the ratio of the elastic work returned in raising a hammer to the total work of fall, when there is spherical impenetration, at any rate, for the harder materials.

In any tests that are to be comparative there should be as few disturbing variables as possible in the conditions, thus in the Brinell test the load and diameter of ball are kept constant, and in the scleroscope test the height of fall and the weight of the hammer are kept constant. On the other hand, provision for non-disturbing variables is desirable for the sake of greater elasticity in the application of the tests. In both of the tests referred to the shape of the depression varies, *i.e.*, the linear dimensions are not in constant proportion for different depths of indentation. It follows that the component stresses of tension, compression and shear, which make up the compound stress producing deformation, have ratios to each other which vary with the depth of depression, and this is one explanation as to why, with the same material, the hardness determined by a tool of a given curvature is different with a different load in tests of the Brinell type and different with a different fall of hammer in tests of the scleroscope type.

When the depression remains of constant shape, such as is given by a conical point (of standard angle, say, 90° in a static test as adopted by Ludwig), then the compound stresses for a given material are induced in constant ratios. Ludwig's cone is thus superior to Brinell's ball, in that any load can be applied without affecting the hardness result. The greater elasticity of the method involving small and large conical depressions that are always similar is a good example of the advantage arising from the application of the principle of similitude, to which subject Dr. Stanton has recently drawn attention in a valuable paper.*

It may be objected that in practice the cone would wear, and that a blunt point would give wrong results, but experiments by the writer have shown that considerable bluntness does not appreciably affect hardness values; this holds so long as the depth of point worn off is not more than one-third the depth of indentation.

A further serious disadvantage of the scleroscope in exact determinations is that the time in which a reading must be taken is very short, and varies inversely as the square root of the reading, so that with soft metals, for which the reading is low, there is a greater liability to a given proportional error than with harder metals. If it is attempted to get greater amounts of rebound by increasing the fall, it has been found in the writer's tests that the ratio of rebound to fall for a given material and weight of hammer is not constant. This is probably due to the resistance to plastic flow being greater with the greater speed of flow with the higher falls.

No simple relation exists between the scleroscope hardness and the Brinell hardness, since the former is dependent on quick plastic deformation and on the absorbed energy of vibration, both of which disturbing effects vary, in a non-proportionate manner, with the material. It is better to rely on a method free from these objections, and this throws us back on the static method, in which it has been pointed out the conical indenting tool is preferable to the spherical one.

As regards the areas to be divided into the load to arrive at hardness. In both the Ludwig and Brinell tests the load is divided by the curved area of depression. The writer's experiments show that both for spherical and conical depressions with various cone angles a more constant ratio is obtained by taking as the denominator the flat projected area of depression. If the flat area be taken this has the advantage of less laborious calculation. Results for two different metals and various cone angles are appended, A_1 and A_2 being the flat and curved areas respectively in square inches.

---

* "The Principle of Similitude Engineering Design," paper read before Section G. of the Brit. Assoc. at Newcastle-on-Tyne, Sept. 7, 1916.

Unwin states that the tensile strength per square inch of reduced area of specimen is about 0·335 of the cone hardness determined with a cone having an angle of 90°.

Angle of Cone.	Load in lbs. F	Muntz Metal.		Mild Steel.	
		$\frac{F}{A_1}$	$\frac{F}{A_2}$	$\frac{F}{A_1}$	$\frac{F}{A_2}$
24° 36′	1115	314,000	67,200	406,000	86,800
43° 20′	,,	261,000	96,500	333,000	129,700
84° 30′	,,	246,000	174,500	267,000	178,500
135° 0′	,,	216,000	199,900	206,000	192,000

It may be of interest to some members to have an explanation of the component stresses that make up the compound stress arising from curved depression. Due to the radial pressure outwards, shown by the arrow in the figure, let the fibres initially occupying the positions A_1 and B_1 be pressed out to positions A_2 and B_2. The shift A_1A_2 must necessarily be greater than B_1B_2, for a greater displacement of metal cannot occur in A_1A_2 than in B_1B_2. Circumferential stresses are induced and on the faces of portion $E_1F_1G_1H_1$, which faces are inclined at 45° to the directions of the compressions and tensions, shear forces as shown are induced, and the final form is shown by $E_2F_2G_2H_2$—lozenge shaped.

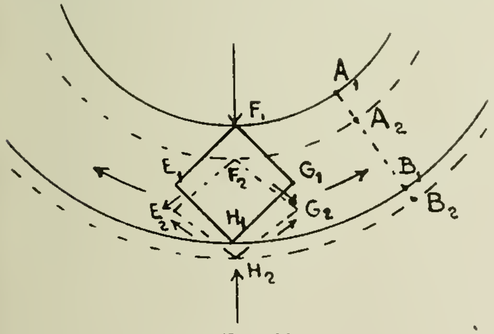


Fig. II.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

South African Drugs and Poisonous Plants.—"A brief review is given of the results of the examination of a number of plant products from South Africa, including *Senecio latifolius*, D.C., *Acokanthera venenata*, G. Don., *Strychnos Henningsii*, Gilg., *Barosma venusta*, Eckl. et Zeyh., and *Kaempferia Ethelo*, J. M. Wood. The bulbs of *Ornithoglossum glaucum*, Salis., 'Cape Slangkop,' a plant which causes cattle poisoning contain a bitter substance of a glucosidic nature, not yet isolated in a pure state, which has an intensely poisonous action typical of the digitalis group of heart poisons. *Homeria pallida* Baker, which occurs commonly in the Transvaal and is said to cause much loss of cattle by poisoning, contains an alkaloid which has not yet been fully investigated. *Crotalaria Burkeana*, Benth., which causes the disease of stock known as 'stiff-sickness,' contains traces of an alkaloid devoid of physiological activity and a number of amorphous products of indefinite character which have not yet been fully investigated. *Chailletia cymosa*, Hook. (*Dichapetalum cymosum*, Hook.), known as 'gift-blad' or 'gift-blaar,' which causes much loss of stock in the Transvaal and in Bechuanaland, was found to contain two resins, one readily soluble and one sparingly soluble in alcohol and both poisonous to animals. No poisonous alkaloid was detected. The roots of *Mesembryanthemum Mahoni*, N.E.Br., used by the natives of the Transvaal to prepare an intoxicating beverage called 'khadi' and by white people as a substitute for yeast in bread-making, were found to contain oxalates equivalent to about 3% of oxalic acid, but no glucosides or alkaloid. The organisms present capable of producing fermentation were a yeast (Torula), *Mucor erectus*, *Aspergillus oryzæ*, and *Aspergillus niger*, the latter mould producing a large amount of oxalic acid when grown on sugar solution." *Bull. Imp. Inst.*, 1916, EC, 27-37. *Journal of the Society of Chemical Industry*, June 30, 1916. p. 706. (J. A. W.)

Potash in Banana Stalks.—"In the course of an examination of the banana stalk for paper making, it was found that the stalk contained potash. In the *Journal Soc. Chem. Ind.*, April, 29, 1916, R. H. Ellis gives the following composition of the stalk:

	Ellis per cent.	Hanley per cent.
Moisture in original stalk ..	91·6	92·7
Dried Matter in original stalk	8·4	7·3
Ash in original stalk ...	2·4	1·5
Potash in origianl stalk ...	1·14	0·9
Ash in dried matter ..	29·9	20·5
Potash in dried matter ..	13·73	12·35
Potash in ash . .	45·9	59·1

Dr Hanley also extracted the juice by pressure in a small meat press, and found it to contain 0·7% potash. From the above figures it will be noted that the dried matter is as rich in potash as kainit. Thus, from the figures, 1 ton of banana stalks will yield 188 lb. of dried matter containing 13·7% of potash, (K_2O), or 54 lb. of ash containing 47·5% potash, or 25 lb. of pure potash. When stripped they have an average weight of 4 lb. each or 16,000 lb. in all, representing 1,310 lb. (about 12 cwt.) of dried matter as rich in potash as kainit."—*Metallurgical and Chemical Engineering*, June 1, 1916, p. 663. (G. H. S.)

New Methods for the Analysis of Lime-Sulphur Solutions.—"*Conclusions.*—Methods are now available for estimating iodometrically the three important forms of sulphur in lime-sulphur solutions—thiosulphate sulphur, mono-sulphur, and poly-sulphur, thiosulphate being the substance directly titrated in each case. The methods appear theoretically sound and practically applicable. The use of a single standard solution which can be so easily and accurately prepared and used as $N/10$ iodine means a possibility of increased accuracy as well as a saving of time over the gravimetric estimation of sulphur as barium sulphate under conditions which demand the employment of an empirical factor."—Robt. M. Chapin, *Journal of Eng. and Industrial Chem.—Chemical News*, July 14, 1916, pp. 20-22. (J. W.)

Determination of Small Quantities of Hydrocyanic Acid. "The accuracy of the results obtained by the colorimetric thiocyanate method of estimating hydrocyanic acid (Francis and Connell, *J. Amer. Chem. Soc.*, 1913, xl, 1624) are vitiated by factors, such as the potassium chloride, or hydrochloric acid present, which influence the ionisation of ferric thiocyanate, and moreover the removal of the sulphur in the method is very tedious. These disadvantages are overcome by the following modification: The hydrocyanic acid is distilled into potassium hydroxide solution and to 50 cc. of the distillate, containing 0·1 to 8 mgm. of potassium cyanide, 1 cc. of yellow ammonium sulphide is added and the liquid is evaporated to dryness in the water bath. The residue is three times extracted with 10 cc. of acetone, the evaporated residue of the acetone extracts, which contains only the potassium thiocyanate, is dissolved in water, made up to 50 cc., 2 cc. of 0·5% ferric chloride solution added, and the colour matched with that of a standard thiocyanate solution. Should the acetone extract be coloured with organic matter this can be removed by extracting the aqueous solution of the residue with ethyl acetate, in which solvent the thiocyanate is insoluble." M. O. Johnson. *Journal Soc. Chem. Industry*, July 15, 1916, p. 735. (A. W.)

Titration of Nitrates with Ferrous Sulphate. *Summary.*—I.—The authors have devised a method based on the well known ferrous sulphate test for nitrates, by which large amounts of nitric acid may be titrated directly.

II.—The accuracy of the method is shown by analyses of known amounts of nitric acid combined and free, comparison being made with the usual standard methods. With care the error does not exceed 1/300 of the quantity of nitric acid estimated. The method is not suitable for traces.

III.—Constancy of conditions is important. The water content should not exceed 25% of the sample titrated, and the temperature should be kept below 60° C. Chlorates, bromates, iodates, chlorides, bromides and iodides interfere, but nitrites do not when sulphuric acid is used as a medium.

IV. A detailed procedure for analysis is given.

V.—Some applications of the method to technical analysis are included; these are now in regular use in several technical laboratories."—F. C. Bowman and W. W. Scott, *Journal of Eng. and Ind. Chem.—Chemical News*, July 28, 1916, pp. 39-41. (J. W.)

METALLURGY.

Alloy Substitutes for Gold and Platinum.—"Experiments proved that: (1) Metals or alloys of metals outside of the precious-metal groups, are unsuitable as substitutes for platinum. The gold and silver alloys of palladium have been found to be excellent substitutes for platinum in its softer forms, and while not so chemically resistant, fill all requirements where conditions are not too rigid. (2) Except in two respects, pure ductile tungsten, and, to a lesser degree, molybdenum, meet all of the specifications of a practical substitute for platinum and its alloys. These two defects are its ease of oxidation, and the difficulty with which it can be soldered; and they have been overcome by coating with a precious metal or alloy, the resultant material being in many ways far superior to platinum or its alloys. This material has met with instant demand, is in many cases replacing the best platinum-iridium alloys, and permits the performance of work which has been impossible with the materials hitherto available. And (3) wrought tungsten and molybdenum were produced on a laboratory scale, but no success attended the attempted production of alloys of tungsten with gold and palladium; while, on the other hand, the alloys of the tungsten-molybdenum series were produced in wrought form. These operations were governed entirely by metallographic control, and their success suggests the possible application of a similar method in a treatment of such metals as iridium, tantalum, rhodium, osmium, etc., in combination with each other, or with tungsten or molybdenum, which may result in the production of alloys possessing properties far superior to those of any material now available."—F. A. Fahrenwald, *Bulletin* 109, A.I.M.E.—*Mining and Scientific Press*, Jan. 22, 1916, p. 136. (G. H. S.)

Application of X-Rays to Metallurgy.—"About one year ago it had been proven that with the proper X-ray equipment and correct time of exposure, blowholes and similar defects could be disclosed in solid metal of considerable thickness. Since that time the special equipment required for this kind of work has been further developed, and several factors essential to systematic and successful routine work have been established: proportion of required time of exposure to thickness of metal; dimensions of smallest air inclusion which could be detected in a given thickness of metal; regulation of electric current to obtain maximum efficiency and best results. Other points which had to be considered were to find the direction from which further progress in the application of X-rays to metallurgical work could be expected, and to establish the technique of metalloradiography.

By ardent research work carried on in this country's finest laboratories, these problems were completely solved The method has already been successfully applied to research work in connection with important metallurgical problems, for instance that of casting copper. If copper is cast without additions, the metal is full of pores and blowholes, mechanically unfit, and of low electric conductivity. The use of boron flux has done away entirely with the difficultly of obtaining sound copper castings of high electrical conductivity. In the difficult research problems of this work, X-ray investigations were applied with much success: stereoscopic radiophotographs of copper castings were taken, so that not only the size, but also the relative depths of the pores could be studied. Without the use of X-rays it would have been necessary to machine off layer after layer of the many sample castings. Even then the experimenter would have had to build up a mental picture of the defects in his casting on the basis of what he has seen on each of the exposed layers. From the radiographs it was possible to see all these defects at once without destroying the castings.

The value of metallo-radiographic equipment for practical testing work will be recognised as soon as the metallurgists will have had occasion to get fully acquainted with the apparatus, using it first, for a while, in pure laboratory work. The metallurgists will then find out in what way the apparatus will assist them in the solution of their manifold individual problems. The method of metalloradiography will be of special value in examining tools, autoclaves, boilers, high-pressure cylinders, valves, saws, machine shafts, roller bearings, gear wheels, axles, cylinders and pistons of internal combustion engines, gun barrels, armour plate, submarine and aeroplane construction parts, etc.

Research work of the most interesting kind has been carried on and is being carried on at present by means of this equipment in the diffraction of X-rays. The atoms in a crystal are arranged in a definite systematic formation and their interatomic distances are of the same general order of magnitude as the wave lengths of X-rays. Prof. Laue of Munich regarded a crystal as a ready-made natural diffraction grating for use with X-rays, but his method is not well adapted to measuring the wave length of X-rays nor to a study of crystal structures. Prof. W. L. Bragg conceived the idea of using a crystal as a reflection grating, and his excellent method possesses the advantage that the results are easly interpreted. Using X-rays and by examining the various orders of spectra from the various crystal planes, Professor Bragg has been able to assign a definite arrangement to the atoms of a crystal. As a result of the wonderful work in X-ray spectra, the Mendelejeff table of elements is to be largely replaced by the Rutherford system of atomic numbers which is based on the fact that, if the elements are arranged in the order of their atomic weights, the "atomic numbers" are proportional to the reciprocal of the square roots of the wave lengths of the characteristic X-rays. The crystallographer is now able to measure the distances between the molecules in crystals and is able to assign a definite structure to them. The chemist now knows that, at least as far as crystals are concerned, there are no such things as molecules in the sense in which the word is ordinarily used in chemistry. The whole crystal is a big complex molecule, and the chemical formula only shows the relative amounts of each element present.

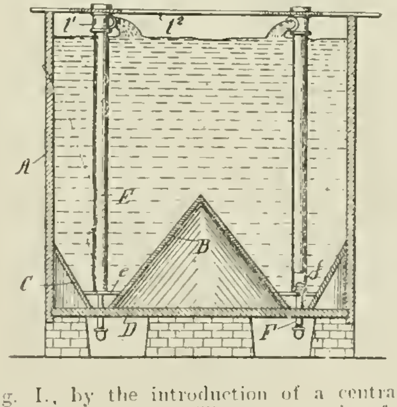
It is reasonable to assume that in metals the crystal, not the molecule, is, next to the atom, the unit to be considered. It has been found that it is possible to use the characteristic X-rays as a means of identifying the various elements, so that in the measurement of the wave length of the characteristic X-rays from a substance we have an accurate method of analysis.

The points mentioned above show the big field opened for the use of X ray equipment in metallurgical laboratories. For both practical work and research an enormous field of study is opened to American metallurgists." *Metallurgical and Chemical Engineering*, March 15, 1916, p. 345. (G. H. S.)

HARDINGE MILLS AT ANACONDA. "At the time it was first decided to remodel the concentrator, it was not definitely known whether pebbles or steel balls would be used for grinding in the Hardinge mills. To provide for this uncertainty a compromise was effected. The mills were made 10 ft. × 4 ft. and built sufficiently strong for steel balls in case balls were used. Each mill was equipped with a 225 h.p. motor directly connected through a flexible coupling. The mill filled with pebbles takes from 95 h.p. to 115 h.p. to operate. In case steel balls were used it was planned to put in a false wood lining back of the steel lining in the cylindrical part of the mill to reduce the effective diameter of the mill.

This latter plan was finally adopted, and the Hardinge mills will be equipped with the false wood lining, 15 in. thick, in the cylindrical part of the mill, and a Cascade steel lining. With this form of lining, the mill is virtually $7\frac{1}{2}$ ft. × 6 ft. and requires about 225 h.p. when loaded with steel balls."—F. LAIST and A. E. WIGGIN.—*Mining and Scientific Press*, March 25, 1916, p. 446. (G. H. S.)

SLIME AGITATOR. "An improvement in the type of agitator commonly known as the 'Parral' is patented by Bernard MacDonald of South Pasadena, Cal. The improvement consists in providing the circular vat with a bottom shaped as shown in Fig. I., by the introduction of a central cone *B* and sloping side *C*. This construction forms a trough into which the settling solids are directed and again drawn up to the top of the vat through the air-lifts *E*. The latter discharge tangentially and cause a swirling motion of the vat contents, thereby keeping them in suspension and affording opportunity for dissolution of the precious metals in the cyanide solution." *Metallurgical and Chemical Engineering*, April 15, 1916, p. 451. (G. H. S.)



MEASUREMENT OF GRAIN SIZE OF METALS.—"The author emphasizes the value to the user of physical tests of metals. Now physical and mechanical properties of metals vary greatly with changes in structure, and in the cases of pure metals and solid solutions the quantitative estimation of the structure can best be made by determining the grain size. Such measurements, however, only become important when correlated with the physical properties of the metal or alloy. The fact that these measurements do not break down the structure of the metal gives them a distinct advantage over mechanical tests in determining, for example, tensile strength or elastic limits, which are dependent on fineness of grain. The method is one of the best available for the determination of the relative quantities of crystalline and amorphous phases, and it is of special value in indicating the life of metals under vibration, in the estimation of the strength properties of alpha brass, in indicating hardness, and in all probability in throwing light on certain corrosion problems.

The following methods for measuring grain size are briefly described: (1) the planimeter method, (2) the Heyn method, (3) the intercept method, (4) the method of comparison with known samples, (5) the author's method. This method, for which great rapidity as well as accuracy is claimed, consists in counting the grains completely included and partly included in the circular portion of an image of the specimen of standard magnification, and by means of an empirical formula determining therefrom the equivalent number of whole grains in the standard area. The apparatus and manipulation required for the measurements are described in some detail and a few simple rules for sampling are laid down. In the interpretation of results care must be taken to distinguish between grain-size and cell-size. In cold-worked metals that have been annealed and sometimes in cast metals the grains will often be elongated, but in elongation due to cold-working measurements parallel and perpendicular to the direction of working show fairly constant ratios.

The President, in commenting on the paper, referred to the enormous tenacity attained by metals at extremely low temperatures, due probably to the closeness of grain. It was unfortunate that a limit was soon reached, for instance, in hardened steel, below which the grain was too fine for Mr. Jeffries' method to be applied. He hoped further research would overcome this difficulty; perhaps some method like Bragg's might be applied. He mentioned that whereas a 0·58% carbon steel contained 5,540 grains per sq. in. as forged, and 4,500 as forged and annealed, the number rose to 330,000 when the steel was water-quenched and reheated."—Z. JEFFRIES, Faraday Society.—*Metallurgical and Chemical Engineering*, June 15, 1916, p. 679. (G. H. S.)

MINING.

TIME AND LABOUR SAVING ON THE MINES—SORTING. "The broad principles which govern the question of sorting or discarding waste rock from the ore mined are as follows:—

1. Sorting is impossible, firstly, where an appreciable proportion of the country rock carries payable values and cannot readily be distinguished from that which is barren, and, secondly, where the waste mined in the stopes exists in narrow bands.
2. Sorting is imperative where the proportion of waste rock broken in the stopes is large, and where such waste rock exists in relatively wide bands and is practically valueless.

The majority of cases, however, fall between these two extremes, and many other factors have to be taken into consideration before it is possible to decide for or against sorting in any particular mine.

The distribution of the gold within the payable area is a factor of great importance. In most mines the gold is confined to the bands of conglomerate, and the quartzite is more or less barren, but, in others, gold exists in the quartzite some little distance away from the reef in a narrow streak carrying carbon and in bands of pyrites running through the quartzite.

In these latter cases the Manager must decide for himself whether the average native or other labourer can be sufficiently trained to distinguish the barren from the gold-bearing rock, and, if such decision is adverse, sorting becomes impossible.

Dealing now with the more usual occurrence when only the bands of conglomerate are payable, and when these are mined with a varying proportion of quartzite carrying little or no gold, the question of sorting, naturally, is influenced by the value of this quartzite and the recovery which can be obtained from it. Probably the most complete data available on this subject is that obtained by the Mines Trial Committee from the experiments carried out on their behalf during 1913 by Mr. Andrew Crosse.

For these experiments samples of waste rock were collected by the Committee from 22 different mines. These samples were assayed and showed values ranging from 0·2 dwt. to 0·35 dwt. and an average value of 0·29 dwt. per ton.

As regards the extraction to be expected from this waste, here, again, valuable information is obtained from the same experiments, concerning which Messrs. Caldecott and White, the members of the Executive Sub-Committee, write as follows:

> "The conclusion to be deduced from an examination of all the figures given is that the extraction to be expected from waste rock, such as is usually being sorted out at present, would not be much lower than that obtained from the ore on any mine, and that an allowance of 5% would in most cases amply cover the deficiency."

On a mine equipped on modern lines, the average extraction which might be expected from reef would be about 96%, so that, if we accept the above statement, the extraction to be expected from waste rock on such a mine would be about 91%.

The next question which arises is the percentage of the barren quartzite which it is possible to sort without undue risk of rejecting valuable gold-bearing rock. This, of course, will vary considerably, according to local conditions. A good rule for arriving at such a figure is to take from the sampling records a large number of complete sections of the reef series (choosing only sections where the reef is fully exposed) and to calculate the probable stoping width therefrom. This can be done, in cases where the reef width plus width of included waste is too narrow for stoping, by adding on a sufficient width of quartzite, and, in the case of wide reefs, by assuming that 15 in. of waste rock over and above the width of the reef series still to be stoped. From these theoretical stope sections the percentage of sorting may be calculated on the assumption that from bands of waste under 4 in. in width nothing will be sorted, and that from other bands of width of 4 in. and over, 50% can be sorted.

Of course, this rule will not be quite accurate for every section, but it is probable that in most cases it will give a figure closely approximating to the percentage of sorting which can be attained.

Having dealt with the possibility of sorting, we now have to consider the circumstances under which it is advisable.

The main points to be taken into account under this head are, the recovery which would be yielded by sortable waste if it were to be treated, and the cost of such treatment.

As regards the recovery to be expected, we have already mentioned that, from the Mines Trials Committee's experiments, the average value of waste rock on these fields is about 0·29 dwt. per ton. This, however, is a figure which cannot be applied indiscriminately, and in order correctly to determine the value of waste rock at any particular mine it would be necessary either to make trial crushings and sample the pulp, or to carry out careful and systematic sampling underground. Should the latter method be employed, a further allowance must be made for the small quantity of reef which almost invariably is included in the waste sorted, particularly on mines where single stage sorting is in operation.

The cost of treatment, necessarily, is a figure which varies within very wide limits on different mines, according to the class of plant and size of units.

As regards the cost of sorting, a native, working efficiently, should be able to sort out 10 tons per diem, which, taking the cost of the native, including compound charges, at 2s. 6d., would be equal to 3d. per ton. The disposal of the sorted waste could be effected for another 1½d., to which might be added a further ½d. per ton for general charges, bringing the total cost of sorting to 5d. per ton.

From figures obtained from two modern and newly-equipped mines, it is found that the average cost of crushing, transport to mill, milling, tube milling, and cyaniding works out at 2s. 7½d. in the one, and 2s. 10½d. in the other case—an average of 2s. 9d.

Suppose now that, at a mine where the above conditions of costs prevailed, the value of the sorted waste was 0·4 dwt. per ton. At a 91% extraction this would yield 0·36 dwt. or 1s. 6d. If everything were milled, 2s. 9d. would be spent on the waste rock and 1s. 6d. would be recovered from it—a net loss of 1s. 3d. On the other hand, if it were sorted out, 5d. would be spent without any return. This case, therefore, shows an advantage of 10d. per ton in favour of sorting.

In the above calculations it has been assumed that the waste rock would have a value of 0·4 dwt. Suppose for a moment that this value was 0·65 dwt.—a by no means uncommon figure. From the latter an extraction of 0·59 dwt. or 2s. 6d. per ton would be expected. In this case, by milling the waste rock, only 3d. per ton would be lost, whereas, if sorted out, it would cost 5d. per ton. Sorting, therefore shows a net loss of 2d. per ton, and the obvious course here is to put the waste rock through the mill and sort nothing at all.

In considering these figures, the case against sorting becomes stronger where a mine is already equipped with a large reduction plant, which is not running at its full capacity. In such a case it would often pay to mill the waste rock even if the recovery value were substantially less than the average cost of treatment.

Suppose, for the sake of example, that, with a mill of 200 stamps, sorting is being carried out, and that, owing to shortage of rock, only 180 stamps are at work. It is extremely likely that the other 20 stamps could be run without extra labour, and with only a small increase in the power cost, particularly in the case of a mill driven by a steam engine. The only other increase in cost, therefore, would be a proportionate charge for stores, such as mercury, cyanide, zinc, oil, grease, etc., dump expenses and the maintenance cost. It is obvious, therefore, that, in such a case, it would pay to stop sorting and run the full mill, since, not only should we obtain extra revenue at a very slightly increased expenditure, but, in addition, the cost of sorting would be saved and the natives employed would be released for work elsewhere.

Conversely, where, owing to antiquated and ill-designed plant, small units, or for other reasons, the extraction is low and reduction costs are high, the question of sorting becomes one of primary importance, and it is imperative to sort up to the economic limit.

In many old plants the extraction from reef may be as low as 93%, and the cost of crushing, transport to mill, tube milling, and cyaniding may be as high as 4s. or even more. In such cases, providing that the mill can be fully supplied with ore, it would pay to sort out waste rock of a value of nearly 1 dwt., calculating on the same basis as before, viz., that the extraction from waste will be 5% less than the extraction from reef, and that sorting will cost 5d. per ton sorted.

In the case of a new mine which has not been equipped with a reduction plant, exactly the same arguments as those already mentioned will apply, with the further consideration that the relative costs of the plants must be taken into account.

This case, however, is not one of vital importance, and scarcely comes within the scope of this Sub-Committee's terms of reference. If, as the result of the investigations previously described, it should be decided not to do sorting, a certain amount undoubtedly would be saved on trommels, belts and buildings, although the saving would not be so great as might be imagined, since provision in any case would have to be made for picking out the hammer heads, ends of jumpers, pieces of wood, and so on, that are found with the ore, in order to prevent them getting into the crushers. Again, the saving in this direction would be counterbalanced by the cost of the extra crushing plant which would have to be erected to deal with the rock which, had sorting been decided upon, would not have been sent to the reduction works.

In the course of writing this report other questions, such as the effect of sorting on the present value of the mine, and the effect of the working capital available upon the policy of working the mine, have suggested themselves, but since they involve financial questions which would be out of place, it has been decided to omit any further reference to them. At the same time, conditions such as these frequently influence the policy of working a mine, and, with it, the question of sorting—particularly in the cases of a new mine which is just starting operations and of a producing mine whose plant is too small and whose financial position does not admit of its being enlarged."—Sub-Committee of Association of Mine Managers of the Transvaal, July 21, 1916, pp. 40-41. (G. H. Sm.)

MISCELLANEOUS.

Surface Combustion.—"Flameless combustion results when a homogeneous explosive mixture of gas and air, in the proper proportions for complete combustion (or with air in slight excess), is caused to burn without flame in contact with a granular incandescent solid, whereby a large proportion of the potential energy of the gas is immediately converted into radiant form. The advantages claimed for the new system are: (1) The combustion is greatly accelerated by the incandescent surface, and may be concentrated just where the heat is required; (2) the combustion is perfect with a minimum excess of air; (3) the attainment of very high temperature is possible without the aid of elaborate regenerative devices; and (4) by reason of the large amount of radiant energy developed, transmission of heat from the seat of combustion to the object to be heated is rapid. These advantages are so uniquely combined in the new system that the resultant heating-effect is, for many important purposes, not only pre-eminently economical but also easy of control. It is obvious that this process is adaptable to many furnace operations, as, for example, the heating of retorts, annealing-furnaces, and the like. It is not essential that the bed of refractory material shall be disposed around the vessel or chamber to be heated; it may be equally well packed into tubes, or the like, traversing the substance to be heated. This latter modification is important in relation to the melting of metals or alloys which are fusible at temperatures below about 600° C., and also in relation to steam-raising in multitubular boilers. By this process, much higher temperatures are attainable with a given gas than the ordinary methods of flame combustion without a regenerative system. In a crucible fired by coal-gas on this system a temperature of 1880° C. is easily reached. Platinum also melts readily. Using air preheated to 500° C. with coal gas, a temperature estimated at somewhat over 2000° C. has been attained. A very resistant chromite, not melting at 1880° C., was fused in this way. Crucibles of alundum are fused without preheating the air. A 110-tube boiler capable of evaporating not less than 5,500 lb. of water per hour showed great economy when fired with coke-oven gas on this system. Vats holding 8 tons or more of molten lead heated by flameless combustion have been proved to utilize about 70% of the calorific energy of the fuel employed."—*Mining and Scientific Press*, Sept. 25, 1915, p. 480. (G. H. S.)

Calcium Chloride for Accelerating Hardening of Concrete. "Hardening of concrete is accelerated by the use of calcium chloride, according to the U.S. Bureau of Standards. It was found that 4% of calcium chloride added to the mixing-water increased the strength of the concrete, at the age of one day, 100% or more. In some cases the strength of two-day old concrete mixed with calcium chloride was as much as 75% of the strength of ordinary-mixed concrete at the end of a month."—*Mining and Scientific Press*, January 29, 1916, p. 173. (G. H. S.)

Abstracts of Patent Applications.

(C.) 237/15. O. Kornelius Olsen (1), John Martin Siebert (2). Improvements in rope supporting rollers for mine shafts, haulage tracks and the like. 23.9.16.

This application relates to rollers for supporting winding or haulage ropes.

(C.) 312/15. R. Hosken. Improvements in the supply of water to hollow rock-drills. 23.12.15.

This application relates to a water connection in a rock drill cylinder head, having a bore in which fits an anvil block or tool shank, a connection through the head to convey water to the said anvil or tool shank, and packing housed in the head on either side of the connection. It applies, of course, only to pneumatic hammer tools and rock drills.

(C.) 205/16. Johan Sigismund Fasting. Improvements in tube mills. 14.8.16.

This application relates to improvements in tube mills, and consists in providing a number of members to protrude within the mill at right angles to the drum axis, to afford lateral support to the material being ground in the intervening divisions thus formed.

(C.) 207/16. Charles Edmund Clews. Improved means for securing cloths to vacuum filter frames. 14.8.16.

This application relates to improvements in means for securing cloths to vacuum filter frames. Present methods are described as consisting in clamping the edge of the filter cloth between battens and the frames by bolts or the like, and the improvement consists in providing a clamp comprising cams and toggle levers, which force rods into grooves provided in the frames to hold the cloth in position.

Changes of Address.

Agnew, J. A., *to* "Royston," West Heath Avenue, Hampstead, London, N.W.

Allen, H. E., *l/o* Benoni: Village Deep G.M. Co., Ltd., P.O. Box 1064, Johannesburg.

Croghan, E. H., *l/o* Johannesburg: 2, Lyford Road, Wandsworth Common, London, S.W.

Filet, G., *to* Tambang Sawah, via Benkoelen, Sumatra, D.E. Indies.

Galbreath, N. M., *l/o* Pretoria: 36a, Lake Avenue, Benoni.

Gill, H. W., *l/o* Johannesburg: Braysdown House, Peasedown St. Johns, near Bath, England.

Hastings, B. J., *l/o* Cleveland: Springs Mines, Ltd., P.O. Box 54, Springs.

Howard, T. C. L., *to* Messina Development Co., Messina, N. Transvaal.

Mauer, L. W., *l/o* Pilgrims Rest: Luipaardsvlei Estate & G.M. Co., P.O. Box 53, Krugersdorp.

Ordman, Driver D., No. 2301, S.A.S.C., Mechanical Transport, c/o Capt. Snow's Convoy, Morogoro, via Dar-es-Salaam.

LIBRARY
APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL

OF THE

Chemical, Metallurgical and Mining Society

OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. DECEMBER 1916. No. 6

Contributions and Correspondence.

REMOVAL OF RUST FROM IRON PLATES.

As a result of experiments recently carried out at the Consolidated Gold Fields Laboratory, an easy, cheap and effective method of removing iron oxide from corroded and pitted iron plates has been evolved. Previous practice on the Rand has been to remove this mechanically, either with hammers, chisels or a sand blast. Whilst largely efficient, each of these methods is liable to leave traces or nodules of rust, especially at the bottom of the pitting, and these nodules prevent the covering of paint adhering to the iron, and form nuclei for further corrosion.

The method evolved consists in applying to the surface of the iron a mixture of finely crushed sodium bisulphate and common salt, in the proportion of two parts of the former to one of the latter. This mixture is prepared, then wetted (just sufficiently to be cohesive) and applied to the iron plate. If time be no object, the moist mixture can be left till the plate is clean but the action is much more rapid if the mixture is scraped off every two or three hours and the iron scrubbed thoroughly with a wire brush, applying water at the same time.. The treatment is repeated till the plate is clean. Usually 24 hours is sufficient for a badly corroded plate

The liberation of hydrochloric acid takes place slowly, and its action on the metallic iron appears to be slight.

When the plate is thoroughly clean it is washed well, finally with an alkaline solution, and dried quickly. A coating of paraffin oil is at once applied to protect the surface against atmospheric action. The metal is then ready for application of paint or other protective covering.

F. W. Watson.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Potassium Bichromate as an Analytical Standard.—"Potassium bichromate by reason of its physical properties and the stability of its solutions, is an excellent analytical standard for oxidation processes (4·9033 gm. per litre = $N/10$ solution). Its equivalents with respect to potassium iodide and ferrous salts by comparison with potassium permanganate are identical within the limits of unavoidable error, or in other words an increased oxidising action on hydrogen iodide over that on ferrous sulphate could not be detected. With different samples of the carefully purified salt differences of 0·10—0·12% were found. Comparison with pure sodium chloride through oxalic acid and permanganate confirmed the hitherto unexplained 'over-value' of potassium bichromate; in the case of one specimen of Kahlbaum's 100 cc. $N/100$ $K_2Cr_2O_7$ = 100·13 cc. $N/100$ NaCl. The over-value was not uniform and varied considerably with different samples. In the indirect standardisation of permanganate solutions against bichromate by means of ferrous solutions, an external indicator may be avoided by adding nearly the requisite quantity of bichromate and finishing off with permanganate. The colour change is clearly visible and may be rendered more evident if desired by adding a small quantity of potassium ferricyanide or of cobalt sulphate to the solution."—I. G. Bruhns.—*Journal of the Society of Chemical Industry*, May 31, 1916, p. 618. (J. A. W.)

Regeneration of Sulphated Storage Cells.—"A paper on this subject was contributed recently to the *Journal of Physical Chemistry*, by Messrs. G. A. Perley and C. W. Davis. The authors have previously shown that sulphated storage cells can be regenerated satisfactorily if the battery acid is replaced by a solution of sodium sulphate. Upon the passage of a normal charging current, the lead sulphate is reduced within 60 hours, even in badly-sulphated grids. This method has since been tried by others with uniformly good results. It was conceivable that some other salt might give deposits that were good enough to justify its use, and, accordingly, some experiments have been made with other sodium salts. The experiments point to the following general conclusions. (1) Sodium sulphate is the best salt to use in regenerating positive and negative storage-battery grids. (2) Dummy positive grids on the outside of the negative plates diminish the time of reduction. (3) Hydrolysis of the lead salts formed in sodium hydroxide solution yields large and troublesome quantities of lead monoxide. The active material of the grids is removed to a considerable extent. (4) With sodium sulphite solutions, a hard crystalline material is deposited at the cathode which causes buckling of the grids. (5) Reduction in whole or in part of a sulphated grid results by the use of a solution of sodium sulphate, carbonate, phosphate or sulphite. (6) Good anode deposits from sulphated grids can be obtained only with sulphate, carbonate and hydroxide solutions. Relatively high anode corrosion with sodium hydroxide solutions makes these useless."—*Indian Engineering*, May 20, 1916, p. 303. (J. A. W.)

SEGREGATION IN GOLD BULLION (CYANIDE).—"In an investigation made on gold (cyanide) bullion practically free from silver but containing base metals other than copper, drillings from near the edges of the bars were found to be extremely variable and generally to contain more gold than dip samples, whilst the latter were usually richer in gold than drillings from the middle portions of the bars. In most cases, drillings and dip samples from the tops were richer in gold than those from the bottoms of the bars, and the points of maximum and minimum richness occurred as often near the middle portions as near the ends. Less segregation occurred when the bullion contained a little silver, bars containing 9% or 10% of the latter being practically homogeneous throughout. Segregation in bullion of this type being probably due to the non-solvent properties of gold towards lead, zinc, and other impurities, the addition of 9% or 10% of silver to cyanide bullion in bulk is suggested as a means of surmounting assaying difficulties without impairing the alloy for subsequent refining."—J. H. HANCE.—*Journal of the Society of Chemical Industry*, May 15, 1916, p. 543. (J. A. W.)

THE PREVENTION OF CORROSION.—"The Cumberland process of preventing corrosion of boilers, condensers and other metal structures in contact with water and other corrosive liquids is now fairly well known to engineers, writes the *Irish Builder and Engineer*, as it has been very widely availed of. The principle involved is the application of an electromotive force to overcome those produced by two dissimilar metals, or the same metal in different conditions in contact with an electrolyte. One or more iron electrodes are fitted in the vessel requiring protection and connected with the positive pole of a small dynamo, the current being continuous and the pressure low, about 8 volts. The negative pole of the dynamo is connected to the vessel, and as the electrodes are insulated from the latter, a current is continually flowing from them to the walls of the vessel, thus causing corrosion of the electrodes only. These can be economically replaced. Boilers so treated are not only saved from corrosion, but the formation of scale is prevented. The current consumption in the case of a condenser is found to be 1 ampere per 500 sq. ft. of cooling surface. In the case of boilers a heavier current is required in order to cope with scale formation, and it is estimated for those of the marine type 1 ampere is necessary per 300 sq. ft. of heating surface. A vessel with twelve Yarrow boilers, the heating surface of each being 4,125 square feet, has been protected from corrosion and kept free from scale with a current of 5 amperes per boiler. In this instance the electrodes consisted of two 7 ft. lengths of 3 in. × $\frac{3}{4}$ in. bar iron, fitted in the steam-drawn joint below the water level."—*Indian Engineering*, June 3, 1916, p. 335. (J. A. W.)

FIVE YEARS' PROGRESS IN THE INDUSTRIAL FELLOWSHIP SYSTEM.—"In March, 1911, the late Robert Kennedy Duncan inaugurated the Industrial Fellowship System at the University of Pittsburgh, in the Department of Industrial Research, now known as the Mellon Institute of Industrial Research of the University of Pittsburgh. The Industrial Fellowship System represents a sane, practical plan of co-operation between industry and learning for increasing the efficiency of American industry.

The first Fellowship was founded through a grant from a baking company, which desired to improve its product. The sum of money given by this concern was used, as has been all the money which has been contributed to Fellowships, with the exception of small sums for the purchase of apparatus and chemicals, to secure the services of a man who had shown a gift for research, to devote all his time to certain problems connected with the baking industry.

During the five years which have elapsed since the establishment of the first Fellowship, 47 distinct concerns have endowed some 105 one-year Fellowships. They did this in the belief that the Mellon Institute was in position to mobilize and to concentrate all of the advantages and opportunities known to science for the solution of their particular problems. The new building of the Institute is the most complete and modern industrial experimental station in the country, and, together with the permanent organization and connection of the Institute, gives very exceptional advantages for the successful prosecution of industrial research work.

The total amount of money contributed to the Institute for the five years ending March 1, 1916, was $360,400. In addition to this sum, over $300,000 was expended by these concerns in the construction of experimental plants and $21,300 was awarded in bonuses to Fellows for the successful completion of problems.

During the five years the Institute itself expended about $175,000 in taking care of the overhead expenses in connection with the Fellowships. Besides this amount, the new building and the permanent equipment of the Institute represent an investment of between $300,000 and $350,000.

That the results obtained under the Industrial Fellowship System of the Mellon Institute have justified the expenditure of these sums of money, both on the part of industrial concerns and the Institute itself, has been shown by the fact that during the first four years—March, 1911, to March, 1915—seven out of each ten problems assigned to the Institute for study were solved to the satisfaction of the donors. A large percentage of the

Fellowships were renewed, showing the confidence which industrialists have in the Institute. Twenty-five patents have been granted to the holders of Fellowships, and there are as many more pending. Above all, some twenty new processes developed in the Institute are now in actual operation on commercial scales.

At the close of the first five years of the Industrial Fellowship System at the Mellon Institute, it can be said that the plan of co-operation between science and industry which it represents has demonstrated its genuine value to American industry, and that the Institute looks forward with hope and confidence to its future development."—*Univ. of Pittsburgh.—Journal of the Franklin Institute*, July, 1916, pp. 129-130. (J. W.)

ATOMIC WEIGHTS OF THE ELEMENTS.—"For the first time since 1912 the International Committee on Atomic Weights (*Journ. Am. Chem. Soc.*, 1915, xxxvii., 2449) recommends changes in the accepted values for a few elements.

	1912.	1916.
Carbon	12·00	12·005
Sulphur	32·07	32·06
Helium	3·99	4·00
Tin	119·0	118·7
Lead	207·10	207·20
Radium	226·4	226·0
Uranium	238·5	238·2
Ytterbium	172·0	173·5
Praseodymium	140·6	140·9
Yttrium	89·0	88·7
Lutecium	174·0	175·0

G. P. BAXTER, *Journal of Am. Chem. Soc.—Chemical News*, Aug. 4., 1916, p. 49. (J. W.)

METALLURGY.

EFFECT OF CLAY IN ORE-DRESSING AND CYANIDING.—"Clay is indispensable in brick and pottery manufacture, while in the treatment of ore it is generally a nuisance. Some clays in ores are not troublesome, but others greatly hinder filtration. In some cases settlement and dewatering of slime is only possible in highly alkaline or acid solutions. Old slime allows decomposition of pyritic and other minerals associated with clay, resulting in decreased efficiency of the cyanide solution.

There is a distinct difference between colloidal and non-colloidal clay, the former being undesirable when treating ore. The weathering of clay has a marked effect on the physical properties of the mineral. Original clay is practically non-absorbent, but the weathered material is highly absorbent.

In its non-colloidal state it is completely unplastic, whereas after decomposition it becomes highly plastic and capable of intricate manipulation. These alterations during weathering are fully utilized in the ceramic industry, where plasticity is, at times, of considerable importance in the manufacture of chinaware. The retentive or absorption powers of certain clays is well known. Adsorption has been defined as the power that clay possesses of removing, from solutions, substances with which it is in contact.

The adsorption of metallic gold is an improbability when consideration is paid to the fact that the gold-potassium-cyanide compound is dissociated in the presence of water into K ions and Au(CN)$_2$ ions. If the latter act as electrolytes by which gold is deposited in place of calcium, then the action is the result of milling in gold-bearing cyanide solution in place of alkaline water; and may be suggested as an explanation to account for the experience of J. W. Hutchinson, borne out by myself and others, that treatment, after crushing in cyanide solution, necessitates a longer time for the recovery of the gold than required when the ore is crushed in water and given a preliminary alkaline treatment. It is also interesting to note that the problem of clarification of solutions after milling-in-cyanide is invariably obtrusive, whereas after milling-in-water trouble is seldom experienced in this direction. In other words, the electrolytic value of gold bearing cyanide solution is inferior to that of lime water; and when once the slime particles are charged with the former no addition of lime will materially hasten coagulation.

A further, and perfectly reasonable assumption may be made, that the gold in the finest condition and associated with the ore may be in the colloidal state. Any clay may actually absorb gold either during or after the process of water absorption. Marshall and Welker have shown that colloidal aluminium hydroxide in the form of a thin jelly is capable of completely absorbing gold from its colloidal solution. This aspect of gold absorption may not need more than passing mention, although it may have a greater bearing on gold recovery processes than we are inclined to admit at present.

In the selective absorptive qualities of clay it is more than likely that gold and silver compounds are absorbed into the structure of the colloid. Their complete recovery may be either impossible or impracticable. Theories regarding dissolved and undissolved gold and silver may have to be modified. Metals that cannot be rapidly washed from colloidal clay may not necessarily be undissolved; it is very likely that they were partly dissolved and later absorbed. Experiments have proved this. When colloidal clay in emulsified form is milled in lime-water, the colloid assumes a temporary equilibrium as far as absorption of water and salts of water is concerned and absorption and adsorption have occurred. Any further interchange of solution will then be a matter of slow dialysis. Hence, when this clay substance comes into contact with cyanide solution, it may be less likely to abstract the dissolved or undissolved metals associated with the ore during the limited time of agitation and treatment.

On the other hand, if a clayey ore is milled in an alkaline cyanide-solution carrying gold, or into which gold immediately dissolves, there is no reason to assume that the colloid will exhibit any selective action to the exclusion of the gold compounds. Absorption equilibrium will then be reached with a gold-bearing solution which can only be displaced with difficulty, or not at all.

Colloids may be divided into suspension colloids and emulsion colloids. The former may be coagulated by mechanical means; they possess marked electrical properties; they can be precipitated by very small quantities of electrolyte; and they possess little or no viscosity in solution. In emulsion colloids, on the other hand, the hydrosols show an absence of electrical phenomena; they form viscous solutions; and are not coagulated until the concentration of the electrolyte in the solution is comparatively high. The common action of emulsoid clay is probably one of absorption. Colloids may be liberated during ore reduction, but not produced, actual observation at the Miami mine, Arizona, proves this.

In wet processes of ore reduction, and when clay compounds are milled and treated in a cyanide solution containing gold, it would seem probable than an absorption of such solution occurs in the honeycomb cells of the colloid, and that subsequent displacement of this metal must necessarily occupy a much longer time than did its absorption. The absorption is due to direct imbition, but displacement under normal conditions is probably due to a slow-acting osmotic pressure when the colloid slime is surrounded with wash solution or water. It is also probable that any absorptive equilibrium is only temporary under such conditions, and that cell content varies with the composition of the surrounding medium.

The question arises as to the relative merits of a slow decantation as compared with a rapid filtration process for the removal of the dissolved metal. It would seem that a combination of the two, in the order stated, would be the most efficient.

It is generally recognised among metallurgists that a considerable time of contact is necessary in washing operations with certain classes of ores; and that theoretical displacement figures do not hold good in practice. From what has already been said, it is apparent that time of wash should not always be based on estimates of gold in solution which is apparently dissolved, as compared with gold associated with the ore which is apparently undissolved. In practical work it is generally found that, although the metal which has been dissolved may be apparently replaced fairly rapidly by ordinary means, a further abstraction of metal from ore occurs after prolonged contact with wash solution. This fact would furnish additional evidence that the gold solution so recovered is, in part at least, being drawn from the cells of the colloid slime, and not merely washed off the surfaces of the slime particles.

At some of the Kalgoorlie mines the value of prolonged washing in filtration treatment is not so obvious, and comparatively short washes are given that abstract a high proportion of recoverable gold from the ore. In this instance it may be assumed that previous roasting treatment has, in some cases, destroyed the colloidal envelope, thus reducing the possibility of absorption to a minimum.

It is obvious that the absorption by clay of bases in solution must affect density of sp. gr. estimations; and the water may contain water of combination that should not be destroyed. Such water is part of the ore. The hygroscopic moisture, on the other hand, must be completely displaced. It is almost impossible to calculate a true hygroscopic moisture percentage in unground rock, or to estimate the actual quantity of dry ore in a large sample with any degree of accuracy. The correction for such moisture in cases where the ore is automatically weighed, or calculated from mine-car content, are often at fault.

He emphasizes the ill-effects on the efficiency of classification and concentration processes when colloid clay forms a constituent of the pulp. To this I agreed in the same journal of July 19, 1913, on the benefits of desliming prior to classification; and also with the question of the accretion of viscous clay on the sides of classifiers, settlers, and similar apparatus. As a remedy in the case of settling-apparatus, I drew attention to the benefits arising from the general adoption of vertical-sided settlers in place of those of the spitzkasten type; and of vertical-sided classifiers in place of cones. Both these types of apparatus are arranged for the mechanical displacement of settled solids

The viscous nature of settled colloidal clay is sufficiently obvious, and any comparative illustrations would be superfluous. On the other hand, the rapid decrease in the fluidity of a pulp, which results from the inclusion of clay in suspension, is considerable. A recent experience in connection with the settling of clay pulp may be of interest to others as it was of anxiety to me at the time. In this instance the amount of clay passing through the mill delivered intimately associated with the ore, and also in the form of pellets and balls of plastic and highly decomposed material, on more than one occasion caused an overload of the settling plant. The result was that the thickening efficiency of the settlers decreased as the amount of colloid material increased, and as soon as the fine slime commenced to overflow from the thickener, practically all the de-watering had stopped. The underflow then contained almost as much water content as the feed into the thickeners.

A further effect of the viscosity of the pulp was then noticeable. Classification became completely disorganised, and the fine sand escaping from the grinding plant was so buoyed up by the viscosity of the pulp that it traversed the radius of the settling tanks with apparent ease, and overflowed at the edges.

Examination of the clay pulp showed that the particles were in the gel form; that no addition or reduction in the amount of lime added had any appreciable effect in hastening settlement; and that the failure to settle was due to the preponderance and accumulation of this material which had absorbed large quantities of water and swelled accordingly. Although the clay entered the plant as unavoidable waste, it left on the residue carrying gold from which it could not be dissociated with ordinary washing methods.

In conclusion it may be said that:

1. The paper has been compiled to explain several points that have obtruded themselves from time to time in practical work. These include: (a) the fact that a complete extraction of gold from even the finest slime is impracticable; (b) the difficulty in the treatment of clay ores, as well as of ores with which clay is associated; (c) the fact that the cyanidation of accumulated clay slime often results in a lower extraction than would have been the case had it been treated direct from the battery; and (d) the fact that the milling of clayey ore in a gold-bearing cyanide solution invariably necessitates a longer time for treatment, and results in a higher residual metal content than would have been the case had it been milled in alkaline water.

2. The facts adduced indicate the highly absorptive properties of colloidal over non-colloidal clay, and show the powers which clays possess of retaining liquids and dissolved salts."—A. W. ALLEN, Inst. of Mining and Metallurgy.—*Mining and Scientific Press*, Feb. 26, 1916, p. 310. (G. H. S.)

STANDARDIZING ROCK-CRUSHING TESTS.—"Reports of rock-crushing tests should include the following details:

1. Description of the machine employed (jaw or gyratory crushers, rolls, stamps, tube-mills, Chilean mills, etc.)

2. Material (timber, concrete, etc.) of foundation. Power is lost in the vibration of poor foundations.

3. Locality, geological, mineralogical, and physi-

cal characters of the rock.

4. The power consumption of the machine with no load and full load: the unit being 1 h.p. per 24 hours.

5. The capacity of the machine in tons (of 2,000 lb.) per 24 hours.

6. The duty in tons per horse-power-day.

7. The screen analysis of feed and product by the proposed A. I. M. E. standard screen-scale.

Toughness of Rock.—Table I. shows the relative duty of the same machine on three different rocks, all other crushing conditions being the same.

This table indicates that the specific resistance of the rock to crushing, may affect the crushing duty of a unit of power as much as 300%. Perhaps this quality may be called toughness. It is not a function of hardness only. For comparison of tests, rocks should be divided into at least three classes in this respect, determined by the crushing strength per square inch.

Screens. For screen analysis, a standard screen-scale, of a uniform ratio between sizes, should be used.

The results of an investigation made by the

Table I. *Relative Crushing Duty of the same Rock-Crushing Machine on Three Different Characters of Rock, all Other Crushing Conditions Being the Same.*

Rock and Feed	Mill	Per Cent. Solids.	H.-P of Machine	Tons per Machine, 24 hours	Tons per H.-P. Day	Tons 200 Mesh per Hp.-Day	Screen Scale -4+10+20-40+60 100+200-200
Calumet and Hecla conglomerate, ¼ mesh.	Conical tube 8ft. by 30in.	40	50·0	65	1·30	0·44	Feed 0 65 29 5 1 ... . Product 3 9 13 41 34
Cœur d'Alêne quartzite, F. M. and S. Co., 5 mm.	Conical tube 8ft. by 22in. 28 r.p.m.	43	47·5	112	2·50	0·67	Feed 0 43 43 11 1 1 1 1 Product . 2 22 18 19 12 27
Miami, ¼ mesh	Conical tube 8ft. by 22in.	27	47·5	229	4·85	1·80	Feed 4 45 33 10 2 2 1 7 Product 2 14 12 17 14 38

Relative crushing duty of 1 h.p. due to character of ore only:—

Calumet and Hecla Conglomerate	1·00
Cœur d'Alêne Quartzite	1·92
Miami	3·75

Table II. *Standard Screen Scale.*

Mesh per Linear Inch	Opening, Inches	Opening, Millimeters	Diameter of Wire, Inches	Diameter of Wire, Millimeters	Area of Openings, Square Inches
	1·20	106·60	0·375	9·52	17·64
	2·97	75·39	0·207	5·26	8·82
	2·10	53·33	0·192	4·88	4·41
	1·49	37·73	0·149	3·78	2·20
	1·05	26·67	0·149	3·78	1·10
	0·742	18·85	0·135	3·43	0·551
	0·525	13·33	0·105	2·67	0·276
	0·371	9·423	0·092	2·34	0·138
3	0·263	6·680	0·070	1·78	0·069
4	0·185	4·699	0·065	1·65	0·034
6	0·131	3·327	0·036	0·91	0·017
8	0·093	2·362	0·032	0·81	0·0086
10	0·065	1·651	0·035	0·89	0·0042
14	0·046	1·168	0·025	0·64	0·0021
20	0·0328	0·833	0·0172	0·44	0·00108
28	0·0232	0·589	0·0125	0·32	0·00054
35	0·0164	0·417	0·0122	0·31	0·00027
48	0·0116	0·295	0·0092	0·23	0·000135
65	0·0082	0·208	0·0072	0·18	0·0000672
100	0·0058	0·147	0·0042	0·11	0·0000336
150	0·0041	0·104	0·0026	0·07	0·0000168
200	0·0029	0·074	0·0021	0·05	0·0000084

U.S. Bureau of Standards, with several of the large mining companies, where 240 to 260 mesh screens are used in connection with flotation tests, and including several cement manufacturers and screen manufacturers, are that a screen-analysis for all rock crushing tests, and practically all testing materials, will be covered by a screen-scale based on the U.S. Bureau of Standards, 200 mesh screen with a square opening of 0·0029 in. and a wire of 0·0021 in. diameter, advancing with a ratio of 1·414 (the square root of 2, suggested by Rittinger) between the successive sizes of screens to a square opening of 4·197 in., the area corresponding to 4 mesh ; for cases finer than 200 mesh, a 280 mesh or 0·0020 opening, with the above ratio, could be used.

If the analysis is to be carried finer than 0·0029 in. (200 mesh), the next finer sieve-opening in the Screen Scale Series, is 0·002 in. (280 mesh)."
—M. K. RODGERS.—*Mining and Scientific Press*, Nov. 6, 1915, p. 711. (G. H. S.)

ALASKA GOLD MINES. — "The fourth annual report of the Alaska Gold Mines Co., for the year 1915, gives many interesting details of a very important and satisfactory year of operations.

The operating profit for the period was $251,848, being 22,581c. per ton treated. To this there should be added $26,923 of miscellaneous income, making the total profit for the year $278,771.

Both mine sampling and mill results on ore from the various stopes, as well as other investigations and analyses of this block, show the highest-grade ore encountered occurring in the schist body as opened in the No. 2 east stope on No. 5 level, and No. 6 east on the No. 9 and No. 10 levels, this schist deposit having a strong rake to the east and consequently appearing farther away from the central shaft and workings on successively deeper levels, until on the No. 10 level it is first encountered east of the No. 2 shaft. The ore from this section has averaged both by sampling and mill results, in excess of $2 per ton, the No. 2 East on the No. 5 level averaging $2·70 per ton, but due to its remoteness from the main shaft, very little development toward preparation for actual mining was done until recently.

Mixture Necessary for Mill-Grade Ore.—It had been originally determined from sampling and analyses of the results obtained before milling operations began, that if a mixture of ore could be made, approximating 25% from the schist orebody east of the shaft, 25% from the slate orebody east of the shaft, and 50% from the slate orebody west of the shaft, ore of an average grade would be sent to the mill so long as these percentages were maintained, and actual results have proved this to be true.

Power-Supply Division. At the Salmon Creek hydro-electric project a new steel transmission line, 8 miles in length, from Salmon Creek through Juneau to the milling plant, was constructed and put in operation, thus completing this project to its maximum efficiency and capacity. The Annex Creek project is capable of a maximum development of 12,000 h.p. at low cost.

The cost of power developed at Salmon Creek and Annex Creek and all other sources during the year was 0·268c. per kw.-hr., or 4·8c. per ton mined and milled. On a basis of 6,000 h.p. this cost was 0·145c. per kw.-hr., or 2·6c. per ton mined and milled.

On January 1, 1915, there was a total of 427,999 tons of broken ore lying in the old stopes as a result of past operations. During the year 1915 there was broken in the stopes, 1,885,100 tons, and in addition to this there was obtained from development work 39,303 tons and from the preparation of stopes, 165,217 tons, or a total of 2,089,620 tons, the total ore broken on December 31, 1915, including that broken prior to January 1, 1915, being 2,517,619 tons. Of this amount 1,116,825 tons were sent to the mill, leaving a balance on hand as of December 31, 1915, of 1,400,984 tons.

The cost of ore breaking during the year 1915 was 22·471c. per ton including 5·25c. per ton charged against mining to create a proper reserve to cover the cost of preparing new stopes as old ones are exhausted ; the actual cost of breaking ore was therefore 17·22c. per ton, and during the month of November, when the maximum tonnage for the year was handled, the cost was 20·1c. per ton including the arbitrary charge for preparing stopes.

At the end of the year the mine had reached a balance through the completion of stopes so that during the ensuing year approximately the same amount of ore will be mined as milled. This is so because the ore broken and remaining in new stopes will be offset by ore drawn from stopes already finished.

Underground tramming from stopes to oreways, by means of storage battery locomotives and automatic dump cars, cost for the year 4·997c. per ton. For the month of maximum tonnage the cost was one cent per ton less. The cost of transporting ore 3½ miles from the mine to the mill was 3·641c. per ton average for the year, and the cost for the month of maximum tonnage was 2·568c. per ton.

The total average cost of ore delivered from the mine to the mill during the year, including prepaid expense and proper apportionment of all general charges, was 31·441c. During the month of November, when 6,000 tons per day was delivered to the mill, the total cost was 28·499c. per ton.

Mill Operations and Costs.—During the year 1915, 1,115,294 tons of ore was milled, having an average value of $1·1569. The average tails were 21·91c., showing an extraction of 81·06%. Prior to the year 1915 there had been milled in the operations, from 1907 to 1912 inclusive, 384,445 tons, averaging $1·949 per ton gross. The total ore milled from the mine up to December 31, 1915, is therefore 1,499,739 tons, having an average head of $1·3532.

While milling operations actually started during the month of February, it was not until the first of March that the first section of the mill was operating under normal conditions. A gradual increase of tonnage was made up to and including the month of November, when an average of 6,000 tons of ore per day was handled.

Throughout each department of the milling plant—that is to say, coarse-crushing, fine-grinding, concentrating and re-treatment plant—the results were equal to or better than originally obtained in experimental work. The average total milling cost for the year was 30·496c. This may be compared with the costs for November of

25·699c., when an average of 6,000 tons of ore per day was put through the mill. At larger capacity costs will be lower. The average total net cost per ton for the year of mining, milling and disposition of products and inclusive of all fixed and general charges, was 69·039c. The cost for November was 59·785c. per ton."—*Engineering and Mining Journal*, April 22, 1916, p. 739. (H. A. W.)

CRYSTAL STRUCTURE OF METALS EXAMINED BY X-RAYS.—"On the occasion of the sixth annual May lecture of the British Institute of Metals, delivered on May 4, at a meeting of the Institute in London, Prof. W. H. Bragg D.Sc., F.R.S. (Nobel Prizeman) gave an interesting account of the new method of applying the properties of X-rays to the study of crystal structure, including the structure of certain metals.

The method, it was shown by the professor, results in the determination of the exact relative positions of the atoms of which the crystal is composed. It is not successful in every case as yet because of the lack of practice and experience of the experimenters in the new field and because some of the interpretations are not fully understood. There is no lack of indications: but we are not yet fully aware of the meaning of all of them.

It is natural to attack first such crystals as have an obviously simple structure and consist of few elements associated in simple proportions. It is also of great advantage if the crystals belong to a group of isomorphous members, such as the rock salt series. This series, in fact, has everything to recommend it to the experimenter: its form is simple, that of the cube; its symmetry is high; it contains two elements only, in equal proportions, *e.g.*, sodium or potassium associated with chlorine or iodine; and there are several members of the series so that we can watch the effect of changing one element at a time. The constitution of this series was, therefore, one of the first to be examined and made plain.

The constitution of the diamond, which has also been determined, presented a rather more difficult task, because the arrangement of the atoms is not so simple as that of the rock salt series, although its form is cubic, its symmetry is high and it contains atoms of one kind only.

Of the metals which will naturally be of especial interest to the Institute of Metals, silver and copper, and by inference gold, have been shown to possess a very simple structure, in which the atoms are arranged as in the piling of shot. Bismuth and antimony have a distorted arrangement; but these two as well as zinc, have not been completely determined. A beginning had been made with iron. The war has, however, stopped all work of the kind on this metal.

This new field of research, according to Professor Bragg, depends on a principle already known. When a regular train of waves falls upon a surface separating two media, part is reflected and part goes on. If the part that goes on meets another separating surface, a second portion is reflected and some of this emerges from the second medium in the same direction as the beam reflected from the first surface. It will happen in general that the two reflected beams are out of phase and to that extent destroy one another. Whether they do or not depends upon the relation between the wave length, the angle of the inclination of the beam to the reflecting surfaces, and the distance between the surfaces. In this way are explained the colours of the soap film, of the thin layer of oil on the surface of a liquid, of the colours of steel when being tempered and so on.

If the reflecting surfaces are many in number, not two, the effect is made more intense and at the same time more precise. It occurs in the beautiful colours of chlorate of potash crystals as shown by Lord Rayleigh. These crystals are formed of alternating layers, twinned across their surfaces of separation; and for some obscure reason the thickness of all the layers is the same though it varies from crystal to crystal. When white light containing all wave lengths is incident upon such a crystal, at a certain angle, then only that wave length is reflected for which the proper relation between the wave length, angle, and spacing holds good. If the angle is altered the wave length which is reflected is no longer the same. Hence the beautiful play of crystal colours.

It is an essential cause of success that the wave length and the spacing are not very different in amount.

We now pass on to the case of the X-rays. These consist of waves—so indeed these very experiments tell us—which are something like 10,000 times shorter than the wave length of light. To obtain the parallel effect we must look for reflecting surfaces which are 10,000 times closer together than the twinning surfaces of the chlorate of potash crystals, and these are separated from one another by only the 40/1000 of an inch or thereabouts. These also Nature has provided in the layers of atoms in the crystal.

It may seem curious that a layer of atoms should act as a reflecting surface; but after all it is not necessary that such a surface should be continuous. A row of iron railings, for example, can act as a reflector of sound waves. A natural face of a crystal contains no doubt a layer of atoms arranged regularly; and behind the natural face are other layers all similar, and placed at regularly increasing distances behind it. Thus all the conditions for this peculiar reflection experiment are present, and we actually find that when a pencil of X-rays of a definite wave length are allowed to fall upon the face of the crystal, and the crystal is gradually turned round so as to alter the angle of incidence, the reflection of the beam as a whole is non-existent except when the angle is right. Then it flashes out strongly. When this angle is observed, the relation of the wave length to the spacing is known.

The instrument used is called the X-ray spectrometer. It has no lenses because X-rays cannot be refracted; and the rays are invisible so that in place of the telescope appears a chamber containing gas which is ionized by the X-rays. The resulting electrical effect is observed in an electroscope. It is important that the measurement of the result is quantitative so that in this respect the new spectrometer has an advantage over the old.

In this way if we use always the same X-ray we can compare the spacings between the layers parallel to one after another of the natural faces parallel to the crystal; and in this way we arrive finally at the crystal structure. The instrument is not at all difficult to use, and the observed effects are large and precise so that it is quite easy to get numerical results. The interpretation is not always quite so easy. One part of it comes readily, viz.: the number of molecules to each unit of the pattern of the crystal—the unit being the smaller part which being reflected again and again without alteration or orientation or distance from its neighbours forms the complete crystal. For instance, the unit of pattern of potassium sulphate contains four molecules; the unit of pattern of antimony contains two atoms.

The far greater difficulty lies in the determination of the way in which the atoms are arranged in the unit. These data are sufficient, but the interpretation is hard."—W. H. Bragg, Institute of Metals.—*Metallurgical and Chemical Engineering*, June 15, 1916, p. 694. (G. H. S.)

MINING.

Advantages of Stronger Detonators. "The Bureau of Mines recommends the use of nothing weaker than No. 6 detonators (blasting caps and electric caps), which recommendation together with reports from the various powder companies regarding unsatisfactory results obtained by users of explosives when detonators weaker than No. 6 are used, led the Institute of Manufacturers of Explosives (which is composed of practically all the powder manufacturers) to ask manufacturers of detonators to make nothing weaker than No. 6. Practically all high explosives manufactured to-day are of the relatively less sensitive type (and consequently safer), but as it is therefore necessary to use a powerful detonator (not weaker than No. 6) to ensure complete detonation, it should be self evident that weak detonators reduce the blasting efficiency of the explosives and increase blasting costs. The United States Government recommends stronger detonators; the Institute of Manufacturers of Explosives recommends stronger detonators; the powder manufacturers recommend stronger detonators. Think this over."—*Mining and Engineering World*, July 22, 1916, p. 149 (H. R. A.)

Time and Labour Saving on the Mines Underground Supervision.—"With special reference to the proper co-operative organization of the work.

In dealing with this subject, your Sub-Committee has taken an ideal mine—large enough to call for every class of supervision—and has tried to sketch the duties which would fall to each official.

It will be recognised from the outset that different mining conditions and local variations call for modifications, which must be decided upon according to circumstances.

We would, however, emphasise the importance of the general rule that to get the best results each official should be given *concrete and well defined work and powers*, with as little overlapping as possible, the aim being to make each overseer feel that he is absolutely responsible within his own sphere to his own immediate chief, and that he will have the confidence and support of such chief, without fear of interference from any higher authority.

Starting from the head of the organisation, and working down, each official should, in criticising or giving orders, work through the next who may immediately be under him. The converse of this only give rise to confusion and misunderstanding and is apt to weaken the hand of junior officials and lessen their interest in their work.

General conferences of all officials, where ideas can be interchanged and subjects thoroughly discussed from many points of view, are considered by many to improve the co-operation of all ranks. On the other hand, it is frequently found that many do not express their real views at such conferences, with the result that unanimity is only apparent.

Whilst it is important to get all officials to pull together, and free interchange of views and a sound mutual understanding is most helpful, the evils of too frequent general conferences must not be lost sight of.

The mutual confidence and trust between individuals, which is necessary for the successful working of any organisation, can probably best be obtained by close personal touch between man and man." Sub-Committee of Association of Mine Managers of the Transvaal.—July 21, 1916, p. 36. (G. H. Sm.)

Abstracts of Patent Applications.

(C.) 190.16. Charles Allen. Slime separator and classifier. 1.8.16.

This application is for an apparatus patent for a combination of double cones, floats, taps, and levers, for the purpose of separating or classifying solids and liquids in the treatment of pulp and slime. It consists of two inverted cones, one inside the other, the outside cone having a discharge at its apex for the solids, and a rim overflow. The floats and levers are for the purpose of automatic regulation.

(C.) 269.15 J. H. Veasey. Improved means for rigging rock drilling machines. 28.10.15.

This application relates to apparatus for mounting rock drills, comprising an hydraulic means for adjusting and securing the supporting column and or the horizontal bar to the column, embodying the principles well known in the hydraulic jack.

(C.) 285.15. Edward Clarke Thorne. Safety incline skip. 17.11.15.

This application relates to a safety device for attachment to skips working in incline shafts of somewhat flat gradient. The device consists of skids so arranged as to be held clear of the rails so long as the rope tension is maintained. In the event of rope breakage a spring action releases a trigger which allows the skids to drop on to the rails close behind the skip wheels, which mount on ramps, forming part of the skids, thus transferring the weight of the skips to the skids; grooves are provided on the underside of the skids with tapering sides, so as to get a wedge grip on the sides of the rail head and the skip is brought to rest by the frictional resistance of the wedge grip.

(C.) 17.16. James V. Snodgrass. Method of preventing the corrosion of pipes, pumps and the like by acid waters.

This application is for the use of powdered magnesite, either raw or calcined, as a neutralizing agent for mine waters.

(C.) 236.16. William John Gee. Method of separating solids from suspension in liquids and apparatus therefor. 16.9.16.

This application is for an apparatus patent for a machine for separating solids from liquids by the action of centrifugal force and by filtration. It comprises an outer rotation drum having an impervious wall, and an inner rotating filter drum through which the liquid is discharged inwardly under pressure.

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. JANUARY 1917. No. 7.

FLOTATION CONCENTRATION EXPERIMENTS ON A TRANSVAAL GOLD ORE.

By F. WARTENWEILER (Member of Council).

(Printed in Journal, November, 1916.)

CONTRIBUTED DISCUSSION.

Mr. N. M. Galbreath *(Member)*: I should like to express my appreciation of Mr. Wartenweiler's interesting and useful paper, which apparently summarizes concisely the best of the work done.

It is difficult for those who have not experimented with this process to realise the great amount of work, which at times is necessary before good results, comparable with practice, can be obtained. It is, therefore, advantageous to us to have for reference a clearly stated record of successful work, such as this one before us.

Fortunately, to-day there is a good amount of literature on the subject, much of which is helpful; and the wide spread and increasing use of the process inspires confidence in it and gives greater interest to the writings on it.

The features of the results given in the paper are:—

(1) Concentration—a good percentage of recovery, a good ratio of concentration, and the values readily recoverable from the concentrate.

(2) The tailing left in a condition amenable to cyaniding.

(3) The elimination of the use of acid and of artificially heated solutions.

At one time many workers believed that heat and acid were essential; gradually, however, as the use of the process widened, heat, in many cases, was omitted; and attempts were made to dispense with acid, as shown by the work of Sanders, Callow and Lyster. In Hoover's recent book it is stated "that some ores can be successfully concentrated without the use of any acid."

When both can be omitted without detriment to concentration considerable economy is effected, as heat costs at least 6d. per ton of ore treated, and acid from 9d. up, depending on conditions. Further, ore containing prohibitive quantities of acid consuming material might then become amenable to the process and the tailing would be left in a better state for cyaniding, should that be wanted. My experience, in the case of our ore, led me to believe that heat was unnecessary, and acid beneficial; and as regards reagents, two kinds were convenient, namely, a frother and a selector.

As regards frothers in general, my experience was somewhat similar to that of the author; creosote is a good standby. Among others which were tried and gave good froths were: turpentine, alcohol and acetic acid. Coming to the reagents which did well in conjunction with creosote were: tar, thin lubricating oils, paraffin, and used engine oil. Eucalyptus oil alone selected and carried well, but the cost is high and the supply limited.

To return to the question of the use of acid in the case before us, and in the meantime leaving out of count the matters of total recovery and profit it would be instructive to know if the use of acid secured any of the following advantages:—

(1) Increase in the percentage saved by flotation alone.

(2) Increase in the tenor of the concentrate.

(3) Decrease in the time of agitation in the frothing box.

As regards the roasting of the concentrate; in view of the value of white arsenic, namely, £37 per ton, it would be interesting to know if the amount driven off would pay to collect.

ORE TREATMENT AT THE FALCON MINE (RHODESIA).

By H. R. Adam, B.Sc. *(Member of Council)*

(Printed in Journal, November, 1916.)

CONTRIBUTED DISCUSSION.

Mr. H. T. Brett *(Member):* It afforded me great pleasure to read the author's paper, and considering the small amount of time he had at his disposal during his visit to the mine, I must congratulate him on the manner in which he described our treatment process.

In the discussion that ensued, I observe that several of those present made rather a point of the fact that we were sending our blister copper to New York for refining. I am glad to see, however, that the author mentioned at the end of the discussion, that this company was forced to send the copper to America, due to the excessive penalty charges for impurities, enforced by the English refineries.

The fact stated however was quite correct, as when this mine started treatment (which was practically simultaneous with the outbreak of war), a sample parcel of blister copper was sent to England and distributed amongst the various refineries, and another parcel was dispatched to New York.

While the English refineries penalise us to a small extent for about 1% impurities, the American refineries make no charge at all.

The penalties for impurities made by the English refineries would not have deterred us from sending our copper to them, but we were surprised to learn that, while the refineries were capable of taking fairly large quantities of blister copper, from 95% upwards for refining, that there were no works large enough to handle anything like our output of 300 tons of blister, containing also gold and silver; most of the copper-gold-silver refining works of the world being in Germany and America. We, therefore, had no alternative but to ship our blister to New York, the special permission of the Imperial Government being first obtained.

Contributions and Correspondence.

COMPARISON OF STAMP MILLING COSTS BETWEEN CALIFORNIAN AND NISSEN STAMPS AT MODDER B.

Californian Costs cover the period January to December, 1913.

Nissen Costs cover the period September, 1915, to August, 1916.

Average Cost in Pence per Ton.

	Californian. d.	Nissen. d.
White wages ...	1·773	0·945
Coloured wages ...	0·402	0·464
Coloured labour sundries	0·281	0·292
Mill spares	0·922	1·296
Shoes and Dies ...	0·909	
Water	0·053	0·309
Sundry stores ...	0·434	0·239
Workshops ...	0·487	0·272
Power	2·857	2·033
Total ...	8·118	5·850
Difference ...	2·268	
Tons milled ...	404,580	167,644

Note.—Comparison made over a period when the respective ages of the plants were approximately equal.

K. L. Graham.

24th October, 1916.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

New Colour Reaction for Aloes.—"A pink coloration is obtained when potassium ferricyanide solution is added to a cold aqueous extract of Barbadoes aloes; the coloration does not develop if either the reagent or test solution is in excess. The reaction may be obtained with a solution containing 1 part of aloes per 10,000 parts. In most cases, the coloration appears after 5 to 15 mins., but its appearance may be rendered more rapid by heating the mixture just to boiling. In more concentrated solutions the colour is deep crimson or blood-red. The substance giving the reaction is only slightly soluble in petroleum spirit, benzene, and chloroform, and is insoluble in ether and ethyl acetate. Socotrine and Cape aloes, and commercial aloin, give a green coloration with the test, whilst aqueous extracts of *Cascara sagrada* or rhubarb do not give any reaction. The coloration yielded by Barbadoes aloes is destroyed by acids and by excess of alkalis; small quantities of alkalis intensify the reaction, at the same time modifying it by introducing a brown tint."—C. E. Stacy, *Analyst.—Journal of the Society of Chemical Industry*, 15th April, 1916, p. 435. (J. W.;

METALLURGY.

NON-CORRODING STEEL.—"Sheet-steel and iron, containing copper, show greatly increased corrosion resistance when exposed to atmospheric conditions. The most effective amount of copper to be used for this purpose is approximately 0·25%. Smaller quantities of copper, down to as little as 0·04%, have a considerable influence in lessening corrosion, but the results are not so good as with the higher amount. Previous investigation has indicated that 0·15% copper is in nearly all cases as efficient as 0·25%. Copper up to 2% gives little or no added benefit. Copper is as necessary in the so-called pure irons to insure corrosion resistance as it is in normal open-hearth and Bessemer steels."—D. M. BUCK and J. O. HANDY, *Jour. of Ind. and Eng. Chem.*—*Mining and Scientific Press*, May 20, 1916, p. 745. (G. H. S.)

CYANIDING COPPER-BEARING ORES.—"The ores of the Baker Mines Co. consist of quartz gangue carrying sulphides of iron, copper, lead and zinc. The gold is partly free, and a large proportion of the silver occurs as sulphide. These ores are treated in a twenty-stamp mill, with amalgamation, and the sand and slime are treated separately, the cyanide treatment consisting of leaching, agitation in Dorr agitators, filtration over Portland filters, and zinc-dust precipitation. Owing to the great distance from the railroad and the consequent high haulage charges the ore is not concentrated, but cyanided direct.

The most objectionable constituent of the ore is copper, which occurs in quantities varying from 0·10% to 0·75%. It is in several forms, the principal ones being primary chalcopyrite, secondary chalcopyrite and carbonate. There is also an occurrence of bornite. An analysis of the mill heads is useless in determining what effect the copper will have because the primary chalcopyrite is only slightly attacked by the solutions, while the other forms of copper dissolve readily. In the operation of the mine and mill, therefore, it is necessary to keep careful watch on the ore being sent to the mill and to mix it in such a manner that the copper content will have the least detrimental effect.

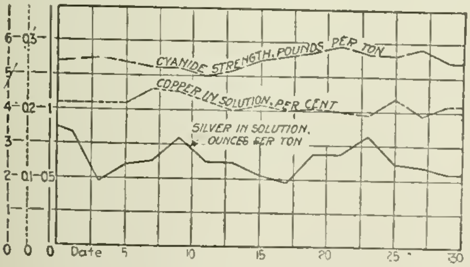


Fig. 1.—*Copper, Silver and Cyanide in Strong Solution, August,* 1915.

Owing to the sulphide character of the ore a rather long leaching period is necessary to obtain a satisfactory extraction, and 5 days of treatment with an average strength of solution of 5·5 lb. to 6 lb. KCN is found necessary. When the copper content becomes too high for economical treatment of the ore, it is manifested in two ways—first, by the rapid dropping off of the solution in cyanide strength and, second, by the reduction of the pregnant solution in silver content, a strong solution being necessary for good silver extraction. The solution naturally shows, also, an increased percentage of copper. Thus the effect of an increase in percentage of easily soluble copper in the ore is noticeable at once. The remedy is, first, to attempt to reduce the copper content in the ore and, second, to bring the solution back to normal strength. The latter cannot be done at once, but must be carried on gradually, depending upon the amount of copper present in the ore and how quickly this can be reduced.

In treating this ore the cyanide consumption is variable, ranging from 1·50 lb. KCN per ton to 4 lb. per ton, but by careful regulation of the ore it is kept to an average of 2 lb. to 2·50 lb. The action of copper and its effect on the solutions is best illustrated by the accompanying diagrams, which are taken from the mill records. They are based on daily assays and analyses of the solutions. Fig. 1 represents a normal month, the variations in silver and copper being due to variations in the grade of the ore. Figs. 2 and 3 represent October and November, 1915, during which period the copper in the ore became troublesome. About October 16 the solution began to drop off in cyanide strength, and the addition of a greatly increased amount of cyanide did not serve to keep it from dropping still further. It was apparent, then, that an undue amount of soluble copper had appeared in the ore. It was inadvisable to increase the additions of cyanide further, as the cyanide was consumed rapidly and in consequence there was a still greater reduction of strength of solution, as shown by the curve in the illustration. At the same time, owing to the lower strength of solution, the silver was reduced to a very small amount. As will be noticed, the copper content of the solution also increased, in spite of the greatly lowered cyanide strength, showing the presence of a large amount of easily

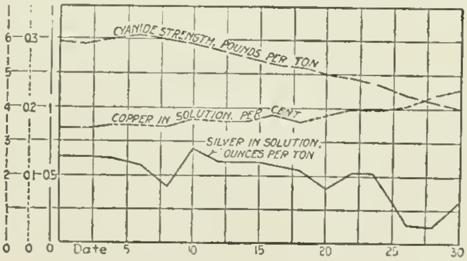


Fig. 2.—*Copper, Silver and Cyanide in Strong Solution, October,* 1915.

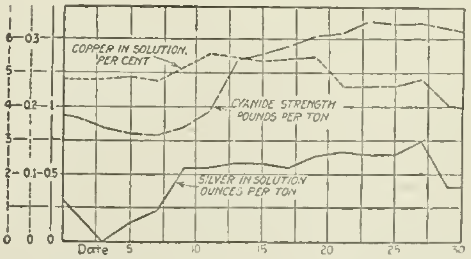


Fig. 3.—*Copper, Silver and Cyanide in Strong Solution, November,* 1915.

soluble copper in the ore. About November 10 the increased additions of cyanide began to take effect and the solution rose rapidly in cyanide strength without any increase of copper content in the solution, showing that the copper of easily soluble composition had passed out of the ore. With the return to normal strength the silver returned to its normal amount in the solution. During the period that the high copper ore was passing through the mill, the cyanide consumption reached a figure of 5 lb. per ton, and even this amount did not serve to raise the solution to its normal strength.

Fig. 4 gives the curves for a period of six months. By reference to the latter part of the period the effect of the copper ore handled during October and November can be seen. The increased consumption of cyanide, coupled with the lower strength of solution and the lessened silver content of the pregnant solution, gives a graphic picture of the effect of copper in the treatment of the ore.

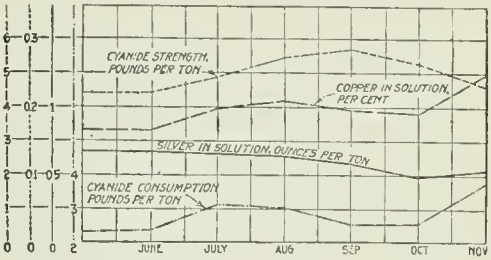


Fig. 4.—*Relation between Cyanide Consumption and Contents of Solutions.*

In the treatment of an ore of this kind it is essential that a complete daily record be kept of the solutions. This, coupled with the fact that there is a considerable variety of ore in the mine, makes it possible to work off gradually the difficult copper ores. The extraction obtained in the plant is normally from 85% to 86% on a grade of $20 to $25 per ton, but this is reduced when copper appears to a detrimental amount, as it did in the example cited previously. The silver extraction is affected to a much greater extent than the gold."—P. W. Gaebelein.—*Engineering and Mining Journal*, July 1, 1916, p. 22. (H. A. W.)

MINING.

Health and Well-Being of Workmen on Witwatersrand Mines.—"*Introductory.*—Of all the factors liable to fluctuation which affect the profits obtainable from the mines, the factor 'workmen' (white and coloured) is considered by the Association to be the most important and the one in which the greatest alteration for good or evil is possible.

A change for the worse may be easily brought about, but the Association feels convinced, that a permanent improvement is impossible, until there can be created a better and more reasonable attitude of mind between all parties.

In the matter of efficiency and discipline the mine natives invariably reflect the attitude of the Europeans with whom they come in contact. To improve the attitude of the European, the present continual distrust, friction and antagonism between white employer and employee must be removed, as a prolongation of this state of affairs will react upon the native and will end only in disaster to the Industry.

The crux lies in the necessity for a genuinely mutual effort between employer and workmen to understand each other's point of view and requirements, and to meet each other in a fair spirit of compromise. Health, safety and general welfare of all employees is of primary importance.

Insufficient attention to health and other conditions in the past has undoubtedly sown seeds of discontent and mistrust, and whilst great improvements have of recent years taken place in such directions, much yet remains to be accomplished, and a few lines of investigation are now brought forward.

Enquiries into some of these suggestions have already taken place, but for one reason or another matters have been shelved, and the Association now wishes to emphasise the importance of re-opening and pushing matters to a conclusion.

In regard to the cost involved in carrying out the recommendations submitted, it may be pointed out that an all-round increase of only 1% in the efficiency of natives employed on these fields would, in effect, increase the labour force by about 2,000 boys.

As the average profit to the Industry in 1914 amounted to about £62 per native employed per annum, this increase in the labour force working at this rate would represent an additional profit of about £124,000 per annum to the Industry.

Further, it may be pointed out that in considering the cost of effecting these improvements, a comparison should be made not only with the present, but also with the state of affairs which may easily arise if well considered reforms are not taken in hand.

Health—General. The Association is of the opinion that physical fitness to perform underground work has a heavy bearing on efficiency, and that it is desirable that this 'fitness' should be more clearly defined for the guidance of both managers and medical men. Men should be impressed with the fact that it is not to their advantage to take up underground work unless really medically fit. Health examination of engine drivers is important and should be universal, if practicable, in the interests of general safety.

It is improbable, though desirable, that any compulsory examination of whites actually at work underground with a view to eliminating the unfit will be brought about in the near future, so that an improvement in the health of the white workers can only be effected in the course of time as the unfit fall out owing to sickness and are replaced by new workers who have undergone proper medical examination.

The present practice of men applying for billets on one mine being examined and refused by the doctor, then going on to the next mine and so on until they are examined by a medical man whose standard of physical fitness may be less exacting, and so receive the necessary certificate of health, is most unsatisfactory and should be prevented.

In view of the frequently recurring instances of this practice, it would appear that the question as to what constitutes fitness for an underground career is either not properly understood or has not been standardised by medical men.

Considerable thought has been given to this question, and the Association is of opinion that the question of the establishment of a Central Bureau should now be vigorously taken up for the systematic examination into the physical fitness of applicants for underground work. The enquiry might take the lines of considering the advisability of establishing a Bureau on the following basis, viz. :—

1. That a Bureau for the medical examination of applicants for underground work on the mines be established, in charge of a staff of whole-time medical men.

2. That a standard of fitness, set in consultation with the Association of Mine Managers, be fixed for such examination.

3. That the decision of the Bureau be final.

4. That an applicant for work shall be examined free of charge by the Bureau, providing that he can produce a certificate signed by a Manager or other authorised person requesting that the bearer of such certificate be examined. Applicants for examination who are not in possession of such a certificate shall be examined on payment of a small fee.

5. That the examination certificate issued by the Bureau be made out in duplicate, with photograph of applicant attached (to prevent possible impersonation), one copy to be kept by the Bureau for record, and one copy to be handed to the applicant and numbered by being pierced. Both photograph and examination certificate should be further stamped with the number of the blasting certificate when the latter is issued by the examining Board.

6. That no applicant who has not previously served underground on the mines be engaged without the necessary certificate of fitness.

7. That the Bureau shall be available for the examination of any underground employee who desires periodically to be informed as to his physical fitness.

A Bureau such as is recommended might possibly be established in connection with the White Labour Bureau of the Public Relief Board.

Health—Natives.—In the foregoing the Association has dealt with the question of health in relation to white employees. Its views, however, regarding the bearing of physical fitness on efficiency are equally applicable to native labourers.

The present system of medical examination of natives recruited for the mines leaves something to be desired, as instanced by the number of natives who have been presumably subjected to such examination at the various recruiting depôts and passed on as fit for mine work, but who on arrival at the mine have been rejected as unfit for mine work and returned to the various labour compounds for repatriation. In addition, no means exist at present to prevent the re-introduction of natives repatriated through unfitness.

The principle of a Central Bureau for medical examination is already established, but such examination might in the opinion of the Association be more thorough. This would, of course, entail a considerable augmentation in the staff of the Bureau, but such system would ensure the more efficient medical examination of those natives.

Further, in the opinion of the Association, the repatriation of natives suffering from tuberculosis is at best but a half measure to combat the disease, and would appear to lend itself to the danger of widening the field of infection, since natives so repatriated on their return to the kraals would spread the infection. The only way to strike at the root of the disease appears to lie in the segregation of natives found suffering from tuberculosis and in their not being allowed to return to their kraals.

The Association is aware of the many difficulties which the carrying out of this step would involve and the danger of adversely affecting recruiting operations thereby. The point is so important that it will require serious consideration, if the spread of tuberculosis amongst natives is to be prevented, and the Association suggests that this question be discussed by a competent Committee on which the Association is represented.

Another matter which the Association considers has an equally important bearing on efficiency is the maintenance of the vitality of natives while at work underground.

The usual practice on the mines is for the native to be given a half-pound loaf of bread to take down with him, when he goes on shift in the morning, for consumption during the shift. Ample food is provided at the compound for natives to eat before leaving the compound, but owing to laziness or the rush to get underground only a small proportion of the natives avail themselves of this hot food. The native eats the loaf at the commencement of his shift and has nothing to sustain his vitality during the latter part of the shift, with the result that he is far too anxious to get back to the compound for a good meal.

In view of the foregoing, the Association recommends that pressure be brought to bear on the natives to make them accept their hot morning ration before they go underground.

Health—Prevention of Miners' Phthisis and Spread of Tuberculosis Underground and Elsewhere.—The question of the prevention of miners' phthisis and tuberculosis, so far as the actual work on the mines is concerned, is at present being exhaustively dealt with by the Miners' Phthisis Prevention Committee, and the Association does not propose to deal with this aspect of the matter.

The Association, however, would point out and emphasise that in campaigning against the spread of tuberculosis it is of opinion that a great deal remains to be done on the surface of mines and by the municipalities and other bodies in their neighbourhood, as well as by the Government.

This question is considered of vital importance to the Industry in that, apart from the effect of the mines themselves becoming supposedly or even actually infected, a very large number of the Industry's most experienced and efficient workers are, first, being rendered inefficient, and, secondly, lost through tuberculosis.

The following are some of the points which, in addition to existing Government and Municipal regulations, the Association considers require the attention and action of the parties concerned :—

1. The prohibition of the following more or less common practices :—

   (*a*) The sale of refuse from compound rooms to dairies and piggeries.

   (*b*) The sale of live and possibly infected animals to mine natives for consumption as food.

   (*c*) The grazing and feeding of stock, especially cows and pigs, near shafts, compounds and locations, where the ground is contaminated by spittle and excretions, and also on depositing sites. The prohibition of fencing off the surface of mining areas should be withdrawn with a view to accomplishing this object.

2. The better control of the food supplied, and the conditions prevailing in Kafir eating-houses.

3. The prevention of dust, with the consequent spread of disease, on main roads by the use of better and less friable material in construction and the more general application of tarry substances with special reference to roads used by miners and motor cars, such, for example as the Main Reef Road.

4. The better control of natives repatriated for tuberculosis and means for preventing them coming back to work on the mines.

There can be no doubt that the interests of the Industry are not being sufficiently safeguarded in regard to tuberculosis, and the Association therefore advises that the Chamber of Mines be recommended to initiate an active campaign against this disease on lines similar to the 'Safety First' movement. The Association would suggest that the object in view could in the first place be reached best by interesting and educating the public by means of illustrated notices, warnings, suggestions and cartoons, posted periodically in prominent places.

The Association also recommends that, in the event of this work being entrusted to a Standing Committee, arrangements be made :—

(1) To ensure a gradual and continuous change in its personnel, and

(2) That the Committee consists of representatives of the bodies concerned, for example, Municipalities, Mining Companies, etc., with medical officers acting in an advisory capacity .

Health—Sanitation.—Several experiments are at present being made with regard to underground sanitation, but up till now no system apparently has been proved better that that at present in use.

It has been stated that the 'Ditchfield' deodoriser, although undoubtedly successful as a deodoriser, does not lessen the danger of bacteria; in fact, it has been pointed out that the absence of odour might cause carelessness in handling and increased danger.

An underground electric furnace is at present being tried as a destructor, but the cost will probably prove excessive.

The Association feels that Regulation No. 158 (a) of the Mining Regulations has the effect of causing latrines to be established in places where they can be easily illuminated, rather than where they are most needed, and therefore recommends that the Government Mining Engineer be asked to rescind it.

The contamination of underground water has in a large number of cases been overlooked. The matter affects to a large extent the health of the natives employed underground. The main source of pollution is the latrines. *These are often placed near gutters of running water, and on cleaning the floor of the latrine the washings are swept into the gutters, the infected water then makes its way to the pump sumps.* In mines where the water for spraying is taken from the sumps or pump columns, the germs are carried by the water service to the working faces, and thus a circuit of infected water is established.

The Association recommends :—

1. That all latrines be so constructed as to avoid this main source of pollution of the underground water.

2. That a bacteriological examination be made periodically of samples of water taken from underground sumps.

3. That when bacteriological examination shows that the water is infected, chloride of lime drips or other means of disinfection be placed at all sumps.

Treatment of the infected water is especially necessary where it is used for spraying.

It will be found that cases of enteric can often be traced to an infected underground water supply.

On the surface, the Association recommends that on mines with reasonably long life a water-borne sewage system connected with septic vats or municipal mains be installed for compounds and hospitals.

Such system would also relieve the underground sanitation in that it would supply a ready means of disposing of excreta.

Working Hours—In connection with which the possibility is considered of some Daylight Saving Scheme.—Under this head it is intended to deal only with the wider aspect of the question, viz., the average time for commencing work. The Association would point out that in its opinion a great deal of time and vitality is at present lost on many mines by sending natives out of the compound and into the mine before it is possible for them to commence work. The Association is convinced that by keeping compound gates closed up to a certain hour and by careful regulation of the blasting time an improvement in this direction is possible.

In regard to the average time for the commencement of work on the mines, it is felt that a drastic and an important alteration is necessary.

On the mines the industrial day begins about 7 a.m., and, all being well, ends between 3 p.m. and 5 p.m., while the social, mercantile and parasitic life begins at about 9 a.m. and ends at any time around midnight.

Bearing in mind that the community on the Witwatersrand is inextricably mixed socially and otherwise, it can be easily understood (1) that the effect of this difference may be more marked here than in some other industrial centres, and (2) that while mine discipline and necessity insist upon the mine worker being up to time in the mornings, the conventions of the majority keep him out of bed in the evenings.

The Association believes that this difference in working hours is responsible for a great deal of ill health, inefficiency and discontent, as well as for sympathy unnecessarily felt by the public for those employed in the mines. The difference is therefore very detrimental to the interests of both employers and employed.

The easiest way to overcome this state of affairs would at first appear to lie in the mines falling into line with the social and mercantile community by commencing work at a later hour.

It is felt that this step would materially improve matters, because, although it is realised that in itself it might be detrimental to the real efficiency of the natives, the Association is sure that the best interests of the Industry are involved with that of a healthy and more or less contented European community.

The Association, however, considers that the best way to overcome the difficulty is for the Government to adopt a special time for the Witwatersrand. It is strongly recommended that the local clock time be advanced one hour, and that, if possible, a differentiation be made between winter and summer, If this recommendation were adopted, work on the mines would commence at the same *actual* time as it does at present, but by the clock, one hour later; while the mercantile and social life would commence at the same clock time as it does now, but by *actual* time one hour earlier.

The units composing the community would thus be brought into more parallel lines, with the result that all of them could better enjoy their leisure hours in company with each other.

Believing as the Association does that good health, contentment and profitable work depend one upon the other, it particularly wishes to emphasise the importance it attaches to any facility for the enjoyment of sunlight and 'day-air,' which would be lost if the first suggestion that the mines start an hour later were adopted.

Social Status—Better Accommodation in the Shape of Larger Houses for Married Men.—The Association urges that the moral effect produced on men by supplying them with decent quarters and surroundings will tend to encourage them to live on the mines and prolong their period of employment with a mine to the advantage of the control of the native labourer, which is a very important factor in considering the question of efficiency and economy.

The Association would therefore call attention to the desirability of providing more houses to accommodate married employees.

It considers that to house permanently a large proportion of married employees is a factor of the greatest importance in maintaining the efficiency of work on the mines.

Assuming that such an economically sound appeal will have effect, then the Association recommends where justifiable :—

1. A further supply of four, five and six-roomed houses to accommodate families of different sizes.
2. That the rent question be met by a varying scale for each size of house.
3. That new houses be built with a view to suitable and pleasant residential sites near the mine.
4. That houses on adjoining mines, as far as possible, be grouped together, to facilitate sanitation, lighting, schooling and other social problems.
5. That structural alterations to houses, subject to the approval of the Management, be permitted, the tenant to bear part of the cost of the alteration.
6. That a cooking range and a bathroom be provided in every house.
7. That an official be appointed to inspect regularly the houses in order to prevent the present wasteful system of repairs due to abuse by tenants.

Social Status—Better Accommodation for Single Men.—The system in general vogue of housing two men in a room is, in the opinion of the Association, detrimental to the efficiency of mine employees.

The Association presumes that no more back quarters for single men will be constructed, and would urge that in the four or five-roomed block, which is superseding the back to back style, a sitting-room fitted with fireplace or radiator be provided for each block.

Bathroom and wash-house accommodation, with hot and cold water supply, should be provided for single men, as also facilities for storing bicycles.

The rents of quarters should be calculated on the basis of one man to one room, and no sharing of rooms should be allowed.

There will still remain on the mines a number of back to back rooms, which have been re-modelled to the requirements of municipalities.

The Association recommends that further action should be taken to improve this accommodation on the following lines :—

1. No more than one man should be allowed to one room.
2. The block should be cut in half transversely, and the middle two rooms concreted out and fitted as bathrooms, and with closets if water-borne sewage system is possible.
3. Where there is no conveniently situated Recreation Hall, the end rooms should be made into sitting-rooms and fitted with fireplaces or radiators.
4. Where blocks are constructed longitudinally parallel to one another, the space between should be screened off by fencing and trees planted, so that each section of rooms, re-modelled as above, would contain sitting-room, bathroom and closet with private enclosure.

The general principle implies that the accommodation be arranged so that men of similar tastes should live near each other, thus rendering possible the creation of a nucleus to operate against lawlessness in thought and action and to encourage loyalty to the employer.

Social Status—Recreation.—This largely depends on the personality of the Manager and Staff on any individual mine, and, as it is obvious that ability to look after men's recreation cannot be seriously considered in selecting men for staff positions on the mines, some other method should be adopted.

For those who have not studied the question of the advantage of sport and recreations on the mines, it may be wise to enumerate the most important benefits :—

1. *Health.*—The effect on health is both direct and indirect, open-air exercise being obviously healthy on the one hand, and on the other hand occupation in any form of reasonable recreation preventing men from remaining in ill-ventilated rooms or in bars.
2. *Keeping Men on the Property.*—This advantage is less obvious, but nevertheless exists, as men who take their recreations together are more likely to work in harmony than those who leave the mine as soon as their work is done. This question of working in harmony is of the utmost importance both among the men and their families, as many cases occur, probably unknown to the Manager, where inefficient work is due to brooding over grievances and lack of friendliness between employees or between the families of these employees.

Taking it, therefore, as granted that it is economically sound for the mines to encourage all forms of sport, and, knowing that no amount of provision of facilities for sport will assist the position unless there is some person in a responsible position who will lead the way in keeping these sports going, the Association arrives at the necessity of maintaining an individual whose entire business it would be to look after sport and recreation.

This man would be whole-time Secretary to the Benefit Society, Recreation Club, and subsidiary clubs. He should be a popular man, energetic and a sportsman himself. It would be his business to find out the lines along which the men are thinking, and to encourage them to provide facilities for any reasonable recreation which they may desire. He should be closely in touch with the Manager, who, as is now the case, can obtain permission from his Board to allow certain expenditure to assist sport.

Where the number of employees on a mine is too small to enable them to pay a good salary (say, £25 to £30 per month) to such man, it would be wise for the Company to give some assistance.

Should this system become more or less universal, the Secretaries of the various mine clubs would meet occasionally and arrange inter-mine competitions, and, in some cases, propose schemes of expenditure for some more expensive sport which would be common to two or more mines in the same neighbourhood."—Appendices to Reports on Time and Labour Saving on the Mines.—Association of Mine Managers of the Transvaal, June 25, 1915, p. 3. (G. H. Sm.)

Abstracts of Patent Applications.

(C.) 230.16 Rudolph Goch Else. Improvements in spraying nozzles. 8.9.16.

This application relates to a spraying nozzle, consisting of a plug cock with a jet-forming port, the said port being rotatable in order to provide for reversing the direction of flow, and the jet impinging upon an inclined surface whereby it is broken up into spray. The second claim provides for a large bore flushing port set at right angles to the port which forms the jet. The third claim provides for a rotatable and renewable disc for the jet to strike upon.

(C.) 240.16. William Marriott. Improvements in or relating to reinforcements for reinforced concrete constructions. 16.9.16.

This application relates to improvements in or relating to reinforcements for reinforced concrete constructions, such as concrete columns, piles, signal posts and other posts, telegraph poles and other poles, piers, beams, girders, railway sleepers and other reinforced concrete construction of the kind in which the metal reinforcement comprises rods or tubes, which are spaced apart and connected together by means of bracings, and constitute a structure of hollow form.

(C.) 242.16 Alfred Leslie Blomfield. Improvements in apparatus for separating liquids from solids in fluid suspensions. 22.9.16.

This application relates to apparatus for separating liquids from solids in a fluid suspension of solids in liquids, and more particularly to apparatus for dividing solids from liquid by what is commonly known as the continuous gravity settling process.

(C.) 257.16 John Marriott Draper. Improvements in apparatus for separating substances of different specific gravities, such as fine coal or ores and the like. 17.10.16.

This application refers to a classifier for coal or ores, of the hindered settling type, applying an upward stream of water. Its essential features comprise a double sorting and balancing column, water steady head, adjustable overflow lip and an elevator for discharging the settled underflow of classified material from a closed settling vat.

(C.) 263.16. Frank Hall (1), Thomas Nicholas Bailey (2). Improvements in or relating to the locking or fastening of cams to shafts. 26.10.16.

This application is for means for locking a cam or the like, having a hole of one diameter, to a shaft by two segments of an eccentric bush, the inner diameter of the bush corresponding to that of the shaft, and its outer diameter to that of the hole in the cam.

(C.) 289.15. William Griffith Williams. Improvements in means or apparatus for separating or concentrating crushed ore products, loose alluvial matter and other fragmentary, granular or pulverulent materials. 22.11.15.

This application relates to improvements in hydraulic classifiers, and consists in an apparatus comprising a concentrating column providing a separating space or chamber into which the material, which is to be concentrated, is delivered, a passage of uniform cross-sectional area for its entire length leading upwards from said space or chamber to the discharge outlet or overflow, and up which passage the gangue or lighter particles of the products are carried by an uprising fluid stream, and a further passage of the same cross-sectional area as the first mentioned passage, said further passage leading downwards from said separating space or chamber, and down which further passage the concentrates or heavier particles of the products fall through the uprising fluid stream, substantially as described.

(C.) 7.16. Margarethe Lesser. Improved concentrator for tin and other ores. 14.1.16.

This application is for a riffle concentrator designed to concentrate ores without the use of water. The machine, as described and shown in drawing, is of the reciprocating table type with air currents acting in conjunction with the table motion to move the materials. The design includes numerous moving parts.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Aimetti, S., *to* Rathfriland, Lochiel Road, Rondebosch, C.P.
Allen, H. E., *l/o* Johannesburg; Geldenhuis Deep, Ltd., P.O. Box 54, Cleveland.
Anderson, P. von M., *l/o* Springs; P.O. Box 1156, Johannesburg.
Dures, R., *l/o* Knights; Sable Antelope, *via* Mumbwa, Rhodesia.
Exter, J. K., *l/o* Johannesburg; c/o Assay Office, State Mines, Brakpan.
Goodwin, G., *l/o* Krugersdorp; P.O. Box 103, Crown Mines.
Hodges, I., *l/o* Vereeniging; 7, Belvedere Avenue, Orangezicht, Cape Town.
Leitch, Q. J., *to* Geldenhuis Deep, Ltd., P.O. Box 54, Cleveland.
Leonard, D. T., *to* Old Nic Mine, Bulawayo, Rhodesia.
Morrell, H. H., *l/o* Germiston; Geldenhuis Deep, Ltd., P.O. Box 54, Cleveland.
Neal, W., *to* 1553, Harvard Avenue, Salt Lake City, Utah, U.S.A.
New, W. S., *to* Robinson Central G.M. Co., P.O. Box 26, Randfontein.
Pyles, J. F., *l/o* Denver; Rose Deep, Ltd., P.O. Box 6, Germiston.
Richardson, A., *to* Department of Scientific and Industrial Research, Great George Street, Westminster, London, S.W.

APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. FEBRUARY 1917. No. 8

Proceedings
AT
Ordinary General Meeting, February 17, 1916.

The Ordinary General Meeting of the Society was held in the South African School of Mines Building, Johannesburg, on Saturday, the 17th February, 1917, Prof. J. A. Wilkinson (President) in the chair. There were also present:—

21 Members: Messrs. J. Gray, H. A. White, H. R. Adam, W. W. Lawrie, H. S. Meyer, F. W. Watson, John Watson, E. M. Weston, A. Whitby, A. F. Crosse, W. R. Dowling, Dr. J. Moir, and J. E. Thomas (Members of Council), H. D. Bell, G. Melvill, P. T. Morrisby, S. Newton, E. A. Osterloh, A. L. Spoor, A. Thomas, and J. H. Veasey.

7 Associates and Students: Messrs. A. M. Anderson, O. A. Gerber, E. G. Harding, L. H. Hyman, R. Railton, H. Ward and J. A. Woodburn.

4 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the last Ordinary General Meeting, held on Saturday, 18th November, 1916, were confirmed.

ELECTION OF NEW MEMBER.

Messrs. A. Whitby and W. R. Dowling were elected scrutineers and, after their scrutiny of the ballot papers, the President declared the following gentleman unanimously elected to membership:

Foersom, O. Strigler, Aurora West G.M. Co., Ltd.,' P.O. Box 26, Maraisburg. Assistant Assayer.

The following had also been admitted by the Council:—

As Associate:

Anderson, Alexander Menzies, Crown Mines, Ltd., P.O. Box 11, Crown Mines. Chief Ambulance Officer.

As Students:

Harding, Ellis George, P.O. Box 214, Germiston. Student.

Railton, Ralph, 9, Mons Road, Bellevue, Johannesburg, Messrs. Littlejohn & Whitby. Learner.

MEMBERS HONOURED.

The President: I have much pleasure in announcing the distinctions that some of our members have achieved. Mr. Pam, a former member of our Council, has been promoted to Captain; Mr. F. J. Trump has won the D.S.O. in Flanders, and been promoted to Lieut.-Colonel in the South Staffordshire Regiment, and one of our honorary members, His Honour F. D. P. Chaplin, has been created a K.C.M.G.

I am sure we are all very happy to hear of these honours, and to those who are serving us in Flanders we send our very heartiest congratulations and wishes that they may soon return to us safe and sound.

General Business.

THE SOLUBILITY OF LIME.

Mr. Andrew F. Crosse *(Past-President)*: I have made rather an interesting observation which I thought might interest some of our members. As you all probably know the text books give the solubility of lime as 1·26 gm. per litre at a temperature of 20° C. I am reckoning the lime as CaO, and not the hydrate. I agitated some good quick-lime for 30 minutes (air agitation). After settling clear at the end of 16 hours it contained 1·47 gm. per litre; the next day it only contained 1·34, and the day after it had become normal.

I made another test under the same conditions, agitating quicklime in water but did not allow it to settle, then filtered and tested the clear solution. This solution contained 1·54 gm. per litre. It might appear to many that this super-saturation is merely an interesting scientific fact, but it has its practical application, which I should like to show in a working model in my laboratory, if any of the members would care to call there and see it.

Mr. A. Whitby *(Member of Council):* What is the text-book figure for the solubility of lime at 0° C.?

Mr. Andrew F. Crosse *(Past-President):* If I remember rightly, it is 1·3 gm. per litre. If I agitate the emulsion of lime with ice I get a super-saturation going up to nearly 2 gm. per litre.

The President: I would like to ask Mr. Crosse what he means by a good quicklime, or lime such as he used?

Mr. Andrew F. Crosse *(Past-President):* We have in South Africa some of the best lime in the world. We have lime, east of Potgietersrust, which contains hardly any impurities. There is also very good lime in other parts of the Union. The only thing is, people here must look upon lime, not as a rough building material which can be used in an ordinary way, but as a valuable alkali. There is no silica in it and hardly any alumina, just some carbonate of magnesia. It is quite excellent for sugar refining, etc. The Natal people, before the war, imported lime from England; we can supply it from at least two places in the Transvaal. Also we have as good magnesia as one would expect to find anywhere in the world.

Mr. A. Whitby *(Member of Council):* There is still one point I want to make with regard to Mr. Crosse's remarks. Nowhere in any text-book is it ever stated that the solubility of lime in water goes more than 1·25 gm. per litre, and yet he says definitely that he has been able to obtain 1·6 or 1·5 gm. per litre solubility. How does it happen that no one else has been able to find a solubility of lime at his figure?

Mr. Andrew F. Crosse *(Past-President):* That was the result of the experiment. 1·5 would be the ordinary amount of CaO per litre when agitating.

Mr. H. A. White *(Vice-President):* In connection with that I should like to point out, what is now a well known fact, that the solubility of any substance, such as barium sulphate or calcium oxide depends to some slight degree on the size of the particles with which the solution is in contact. Connected with this is the possibility of considerable super-saturation in the absence of nuclei. I think that throws some little light on the subject.

Mr. John Watson *(Member of Council):* Regarding the solubility of lime in water, I should like to ask Mr. Crosse if any determination of carbonic acid in the water used in his experiments had been made.

In August, 1915, Mr. Andrews, chief chemist to the Victoria Falls Power Co., showed, to the S.A. Association of Analytical Chemists, an apparatus for testing the purity of water by its electrical conductivity, which showed that the sample of distilled water supplied contained an appreciable amount of carbonic acid. Now, chemists and geologists are both aware of the fact that limestone and dolomite are much more soluble in a solution of carbonic acid than in pure water.

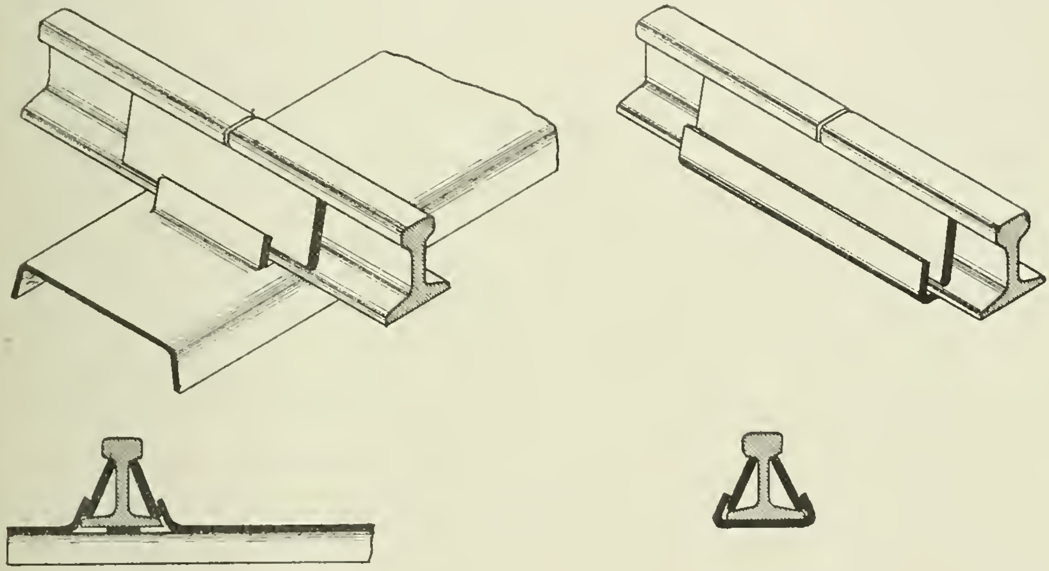
Mr. Andrew F. Crosse *(Past-President):* First of all, I agitated good quicklime in water, as much as 160 litres, and I obtained this result which made me think something was wrong. Then I repeated it in smaller quantities. It seems that when this very finely divided lime is agitated by air in that way a higher percentage is dissolved. I agitated it for 15 or 20 minutes, with air, with a large excess of lime, I obtained 1·45, 1·5, or 1·54; quite an excess over the theory. I am merely bringing this matter up; I do not explain the reason.

Dr. J. Moir *(Past-President):* Mr. Crosse has stated that his clear supersaturated solution, on keeping, goes down to the normal strength of 1·2 gm. I would like to ask him whether, when it does that, there is any visible deposit of solid, and if he has made sure it is not carbonate instead of hydrate?

Mr. Andrew F. Crosse *(Past-President)*: It is a very fair question to ask; but I am afraid I did not take notice while experimenting.

A NEW TRACK AND RAIL JOINT.

Mr. L. W. Macer *(Associate)*: The jointing arrangement consists of a base plate, 6 in. long of $\frac{1}{8}$ in. steel plate, with longitudinal flanges formed to make an easy fit with the flange of the rail and two wedges of 3/16 in. plate having a taper of $\frac{1}{4}$ in. per foot, which are wedged between the under part of the rail head and the flange of the base plate, the wedges being placed on each side of the rail.



—SECTION.—

—SECTION.—

Railway Track and Rail Joint.

In the sleeper the base is formed by punching up lugs to form the flanges to receive the wedges, and the advantage is gained of being able to make the joints on the sleeper, giving great permanency of alignment to the track. The rails can be supported between joints by wooden track ties to which rails are dog spiked, or by lighter sleepers of the wedged type, but using only one wedge or key.

The advantages over the ordinary method of fishplates and bolts are:—

First Cost.—The arrangement consisting solely of stampings from sheet steel, the labour involved in manufacture is negligible. The wedge joint for 16 lb. per yard rails weighs 3 lb. 2 oz., against 4 lb. 3 oz. for two fishplates and 4 bolts, showing a considerable saving in metal. The sleeper also is simpler, as it is a plain stamping and avoids the necessity of clutch bolts.

Maintenance.—Fish bolts, sleeper bolts, and in many cases also fish plates, are never used a second time, and in places where track is frequently moved, such as on tailings dumps, the expenditure on bolts especially, is considerable. The wedged joint can be taken adrift easily and replaced as often as necessary until corrosion renders it too weak for further use.

Strength.—The triangular section formed by the wedges and base plate form an arrangement of great strength, as the metal is placed where needed to resist both vertical and lateral bending. Tests indicate that the joint is stiffer than the rail itself, and alignment at the joints is perfect and permanent.

Speed in Track Laying.—The method is particularly suited to the native plate layer, who, as a rule, is not an adept with the spanner. In a practical test it was found that five wedged joints were completed during the time one fished joint was made.

An additional advantage is that the joints can be made from scrap cuttings of 3/16 in. and ⅛ in. plate, of which hundreds of tons are to be found upon the mines. By means of a die and the mine steam hammer the scrap material can be quickly turned into serviceable wedged joints.

The track is particularly suited to the conditions obtaining in flat stopes and on dumps.

Mr. E. M. Weston *(Member of Council)*: I notice that apparently one could not make a joint on a bend, but I do not know that that is altogether a disadvantage. One sees too many joints on bends; but sometimes it is necessary, and in that case the ordinary fish-plate joint could be used. Otherwise it seems a splendid and a simple idea.

WINNERS OF SOCIETY'S PRIZES.

The President: The Principal of the School of Mines has sent the list of awards of the prizes which were offered by this Society for competition at the Evening Class Examinations held in November last year, and I have pleasure in announcing them:—

Inorganic Chemistry:

Stage I.—Theoretical: *Book Prize Value*
G. Drewett ... ... 10s. 6d.
O. L. Oehse ... ... 10s. 6d.
Stage I.—Practical: R. S. Cunliff £1 1s.
Stage II.—Theoretical: No award.
Stage II.—Practical: M. Marcuson £1 1s.
Stage III.—Theoretical:
R. Railton ... ... £1 1s.
Stage III.—Practical: R. Railton £1 1s.
Society's Bronze Medal: R. Railton.

Metallurgy:

Stage I.—O. L. Oehse ... ... £1 1s.

Metallurgy of Gold:

R. Railton ... ... £1 1s.

No awards were made for Assaying, Stages I. and II., nor for Metallography.

The President: I have much pleasure in congratulating those students on their success and I hope they will come forward, in the future, and do some chemical and metallurgical work and give us the benefit of their results.

PROPOSED VISIT TO GOVERNMENT LABORATORY OF VETERINARY RESEARCH.

The President: I have also received, this evening, a letter from Sir Arnold Theiler, in reply to a request made by me a few days ago, namely, that he should grant the Society the privilege of visiting the Government Laboratory of Veterinary Research, at Onderstepoort, Pretoria. He states that this will be feasible about September next, and I hope that my successor in office will make the necessary arrangements.

COMPARISON OF STAMP MILLING COSTS.

Mr. H. A. White *(Vice-President)*: I would like to express the thanks of this Society to Mr. K. L. Graham for the interesting comparison of costs between Nissen and Rand heavy stamps (published in the January *Journal*, p. 118).

The only other figures published bearing on this point are those mentioned incidentally in Mr. Bosqui's paper on Metallurgical Practice in the Witwatersrand District, read before the American Institution of Mining Engineers, in September, 1915. In this earlier information it may be noted that costs for milling on Modder B. were raised 0·6d. on the introduction of 16 Nissen stamps in November, 1914, in spite of decrease in all other reduction costs due to the increase of tonnage from 33,700 to 42,000 tons.

It is perhaps unfortunate that the figures now presented for the Rand stamps are for a period four years ago, when the tonnage was smaller and the "steady reduction in cost of treatment" referred to by Mr. Bosqui was not so far developed. The Nissen stamp figures on the other hand are more recent, are connected with a larger tonnage, and judging from the increased provision of tubes considered necessary by Mr. Bosqui (Trans. Amer. Inst. M. E., Vol. 52, p. 65), it may be assumed that the grading of pulp delivered is much coarser.

It would be very interesting to obtain, if possible, a comparison of costs between the modern Rand stamp mill with 2,000 lb. stamps and screen aperture of ½ in. and the latest form of Nissen stamp. To render such a comparison of real service it would be necessary for the figures to refer to

(1) Similar ore;
(2) Similar screen grading of pulp, and
(3) To the same year of operation.

In order to avoid any misapprehension I desire to record my opinion that the obvious advantages of the Nissen stamp arrangements should result in some economy of operation, and to acknowledge the difficulty of getting reliable information respecting costs in such a case as the Modder B., where both kinds of stamps are in use, and consequently various opinions as to correct allocation of important cost items might be held.

NEW APPLICATIONS OF THYMOLPHTHALEIN AND NAPHTHOLPHTHALEIN, INCLUDING RAPID METHODS FOR ANALYSING LIMESTONE AND AMMONIUM SALTS.

By James Moir, M.A., D.Sc., F.I.C.
(Past-President).

(a) A Rapid Method of Analysing Limestone by Titration.—

The indicator thymolphthalein is one which, although little known to the generality of chemists, possesses certain qualities which distinguish it from almost all other indicators, and render it capable of being used to solve problems in analytical chemistry which cannot be solved by the use of the common indicators. The particular property I refer to is that of being insensitive to minute traces of alkali, particularly at the boiling point; and the application of this property to the analysis of limestone depends on the fact that when magnesium hydrate is coagulated (presumably dehydrated) by boiling, it becomes so insoluble that, strong base as it is, it is then incapable of affecting this indicator, although it still colours phenolphthalein. In consequence of this property, it is possible to determine CaO and MgO in a limestone by titration in about 30 minutes. The following is the process: The requisites are (1) 2*N* hydrochloric acid,* made by diluting concentrated HCl five times and carefully standardising 20 cc. against pure crystalline $KHCO_3$ with methylorange; the third place of decimals in the factor of this acid must be accurately ascertained, (2) accurate *N*/2 NaOH made from material free from carbonate and with boiled distilled water; this to be standardised *with phenolphthalein*, (3) a small quantity of *N*/2 HCl, (4) 1% solution of thymolphthalein in 60% or 70% alcohol, (5) 0·02% solution of methylred in dilute alcohol.

The carefully sampled and mixed limestone is brought to 60 mesh, and from ½ gm. to ¾ gm. is thoroughly agated in 2 or 3 portions until the powder is perfectly gritless, weighed (to 3 places only) and transferred to a high narrow beaker with cover-glass. A *narrow* 10 cc. burette is filled with the 2*N* acid, and from 9·5 to 10 cc. of the acid are run in at once and *immediately* mixed with the powder so that no dry portion remains; after half a minute the adhering drop of acid near the top of the beaker is washed down with 1 or 2 cc. of water and the beaker placed on the steam-bath for 20 minutes (if $MgCO_3$ is small in amount, 5 minutes will suffice); meanwhile two other burettes (common ones will do) are filled to the zero with *N*/2 soda and *N*/2 HCl respectively. The narrow burette from which the 2*N* HCl has been run is then read, several minutes having elapsed so that it shall have run down properly, as it is necessary to read the quantity used accurately to two places of decimals. The turbid solution of the limestone is then diluted to about 20 cc., treated with some methylorange, and the *N*/2 NaOH run in until the red methylorange has turned yellowish-salmon: if ½ gm. sample has been taken and 9·5 cc. acid, then 18 cc. NaOH can be run in at once, and the rest slowly: then methylred solution is added to a strong pink colour, and the titration finished *drop by drop* to pure yellow. The methyl orange is used merely as a warning of the approach of the end-point, and a skilled operator may omit it: nevertheless time is saved if the operator has the warning given by methylorange.

The amount of 2*N* HCl multiplied by 4 (and the HCl factor) is the true *N*/2 HCl originally used to dissolve the sample, and this, less the *N*/2 NaOH required to the methylred end point, gives the acid-equivalent of the CaO and MgO together.

To determine the MgO, the neutralised liquid is diluted to at least 50 cc. and boiled for a minute. Longer boiling to displace the CO_2 is unnecessary, as the bulk has disappeared in the first effervescence with undiluted acid. Thereon about 3 cc. of thymolphthalein solution is added, followed by a *known* quantity of the *N*/2 NaOH sufficient to give a *dark* inky blue (dichroic red-green in artificial light); and the mixture is boiled for a minute to coagulate the precipitated magnesia. Since 1 cc. of NaOH corresponds to 2% MgO on a ½ gm. sample, it is important not to add a *great* excess of NaOH at this stage, but a very dolomitic sample may require 10 or 15 cc. before a blue is obtained that will stand boiling. The blue suspension having been obtained, the mixture is *vigorously stirred* while titrating back to yellow (through green) with $N/2$ HCl, when just at the end point, a transient red spot (due to acid methylred) will appear in the pale green mixture. It is important not to overshoot this end-point, since owing to the presence of MgO, the mixture remains yellowish, although over done.

---

* Weaker acid would fail to dissolve $MgCO_3$ if present; 2 *N* acid is not volatile on the steam bath, only giving off steam, not acid.

The known NaOH added to give the blue less the HCl required to restore yellow is a measure of the precipitated magnesia, therefore each cc. × 0·0101 = wt. of MgO. The factor is MgO/4, because Mg is divalent and $N/2$ NaOH has been used.

Finally, to get the CaO, subtract the cc. NaOH used in the magnesia calculation from the cc. mentioned above as acid equivalent, the difference being the acid-equivalent of the CaO alone, and this in cc. × 0·01403 = wt. of CaO present.

It should be noted that the second addition of NaOH liberates $Ca(OH)_2$ as well as MgO, but as $Ca(OH)_2$ is soluble at the dilution used it affects thymolphthalein just as much as NaOH does, and therefore does not use up NaOH. Nevertheless, being very sensitive to CO_2 it must not be exposed to it, for example, by unnecessarily long boiling over a bunsen or by allowing oneself to be interrupted at this stage of the process.

The theoretical CO_2 in the sample can also be calculated by multiplying the acid-equivalent in cc. by 0·011, and in 9 cases out of 10 agrees within 1% with the loss on ignition of the sample, the latter being nearly always larger owing to moisture and organic matter, if present. Finally, the "silica insoluble" of the sample can be obtained by adding to the final product of the titration a little $N/2$ HCl—just enough to dissolve the Mg, Fe and Al in the precipitate and to cause a red colour which resists boiling, and after a couple of minutes' boiling, filtering off, washing and igniting: even gelatinous silica is coagulated by the numerous boilings done close to the true neutral point.

A rough estimate of the alumina in a limestone which does not contain much iron can also be got from the difference between the methylorange and methylred end points at the beginning: the Al is in solution as AlOCl at the former end point and precipitated at the latter: therefore the difference of the titrations (with $N/2$ NaOH $= N/2$ AlOCl $= M/4$ Al_2O_3 as the basis of calculation) gives the amount of alumina: this is however, only rough, since the methylorange end point cannot be accurately ascertained.

Since the calculations are complex it is desirable to eliminate all acid and alkali factors: time spent on accurately adjusting the three solutions to the factor 1·000 will repay itself afterwards.*

It will be as well if I give an example of the calculation in the case where the factor is not 1·0: Suppose 0·681 gm. of agated limestone has been treated with 9·72 cc. of the strong HCl (say, 2N × 1·007) and that 14·2 cc. $N/2$ NaOH of factor 0·993 were required to reach the methylred end point. The original true $N/2$ acid used is 9·72 × 1·007 × 4 or 39·15 cc., and this less 14·1 cc. (the NaOH corrected for its factor) or 25·05 cc. is the acid-equivalent of the CaO + MgO in the sample. Suppose then that after the thymolphthalein 2·0 cc. NaOH were added to get a permanent blue and thereafter 0·65 cc. HCl used to remove the blue colour, the difference due to magnesia is 1·35 cc. The percentage of magnesia is

1·35 × 0·0101 × 100 ÷ 0·681 = 2·00 %.

In this case the NaOH factor is so close to 1·0 that it may be ignored. Next subtract 1·35 from 25·05, and the difference is the acid-equivalent of the CaO alone, namely, 23·70, and the percentage of CaO is

23·70 × 0·01403 × 100 ÷ 0·681, or 48·9%.

Again the calculated (or theoretical) CO_2 is

25·05 × 0·011 × 100 ÷ 0·681, or 40·5%.

In this case we thus account for 91·4% of the sample, the balance being silica, alumina, iron-oxide, water, organic matter, phosphoric and sulphuric anhydrides and alkalis, many of which are usually absent: but it should be noted that when SO_3 is present, the CaO found is low by a corresponding amount, and should be corrected if the SO_3 is worth counting. My process only determines lime and magnesia present as carbonates, oxides, or silicates, *i.e.*, in so far as combined with weak acids. As regards P_2O_5, if it is found to be present in appreciable amounts, the CaO found by titration should be increased by $0·4 \times P_2O$ since in titration $Ca_3(PO_4)_2$ goes to $Ca(H_2PO_4)_2$.

Some results are appended of analyses

---

* This factor is sensitive to changes of temperature: if it is 1·000 at 25C, it is 0·998 at 29C, and 1·002 at 21C.

done on the same sample by the new method and by the ordinary one.

NEW METHOD.

	Sample A	Sample B	Sample C	Sample D
Found CaO ...	45·6	27·1	36·1	47·5
Found MgO ...	3·2	12·5	6·5	6·9
Calc. CO_2 ...	39·4	54·9	35·4	44·1

ROUTINE METHOD.

	Sample A	Sample B	Sample C	Sample D
Found CaO ...	45·8	26·9	36·2	47·0
Found MgO ...	2·9	12·2	6·4	7·1
Loss in ignition	39·75	34·8	36·0	43·5

(b) New Method of Determining Ammonium Salts by Titration.—

This section gives another example of the use of the peculiar indicator thymolphthalein (see preceding section). The object of the new process is to determine ammonia in its neutral salts as occurring in explosives, fertilisers, etc., without the trouble of distillation. Thus explosives may contain $KNO_3 + AmNO_3$, the sum of which is obtained by water-extraction after removing nitro-glycerine and similar substances by ether, whereon the $AmNO_3$ may be determined by the new process, giving the other salts by difference.

The process depends on the fact that ammonia is a weak base and is unable to affect certain indicators like thymolphthalein* unless it is present in large quantity. The "avidity" of NH_4OH is about 1/54 of that of NaOH, so N/10 ammonia only affects indicators as N/540 NaOH would do. The solution is heated to boiling, having been previously made neutral, if necessary (Methylred is the best indicator for this) and titrated with sodium hydrate (N/5 is best) in presence of thymolphthalein (small quantity of saturated solution in 50% alcohol). A pale-blue colour appears as the endpoint is approached and the solution is again boiled till colourless, and more NaOH added until the blue colour is deep and withstands boiling for 20 seconds: it is not necessary to boil off all the ammonia as would be the case were the common indicators used. A correction of 0·20 cc. is subtracted and the corrected amount of NaOH used then corresponds to N/5 NH_3 in the original solution of the salts. The first appearance of the pale blue occurs when about 90% of the NaOH has been added. It should be noted that if methylred has been added, the colorations are green instead of blue. The solution to be titrated should contain about 1% ammonium salts.

The following are results obtained by the method:

(1) *Am_2SO_4*. 10 cc. N/10 Am_2SO_4 required 5·15 cc. 4·95 corrected 99% of theory.

15 cc. required 7·70 cc. = 7·50 cc corrected = 100% of theory.

40 cc. required 20·12 cc. 19·92 cc. corrected = 99·6% of theory.

(2) *AmCl* (dried) 0·1640 in 20 cc. water required 15·55 cc. 15·35 cc. corrected = 100·1% of theory.

(3) $AmNO_3$ (dried) 0·1450 in 20 cc. water required 9·28 cc. = 9·08 cc. corrected = 100·2% of theory.

(4) $Am_2C_2O_4.H_2O$ 0·2470 used 17·55 cc. corrected = 101% of theory (possibly the specimen had effloresced).

(5) $AmClO_4$ commercial containing 2·0% $NaClO_4$, 0·435 used 18·10 cc. = 97·8% true $AmClO_4$.

(6) Am_2HPO_4 (methylred cannot be used) 0·1685 used 13·15 cc. NaOH = 102·9% of theory.

It will be seen that the method does not work very well with ammonium salts of weak acids.

(c) The Determination of True Neutrality in Waters by Means of Mixed Indicators.—

The method of mixed indicators is well known, particularly the use of methyl-orange mixed with phenolphthalein, which is yellow near neutrality and pink if either acid or alkaline. This mixture is, however, quite insensitive and will not detect less than 2 parts per 100,000 H_2SO_4, or $Ca(OH)_2$, *i.e.*, it remains yellow or salmon-coloured over the whole of this range of acidity or alkalinity; also the fact that a salmon colour may mean either slight acidity or slight alkalinity is a fatal drawback. My improvement consists in using indicators which are 10 or 20 times as sensitive, and the particular mixture which I recommend is one of methylred (orthocarboxylic acid of "butter-yellow") with *a*-naphtholphthalein, which in addition are chosen so that the alkaline colour of the one shall be as different as possible from the acid colour of the other. This mixture added to a water will detect 0·1 part H_2SO_4 and 0·2 part $Ca(OH)_2$ per 100,000. The acid colour is violet-rose (with any amount of acid greater than 0·4 per 100,000); the colour in presence of 0·2 parts acid is salmon-orange, the neutral colour is straw-yellow; the colour in presence of 0·2 parts alkali is citrine-green, and the full alkaline colour (over 0·4 parts alkali) is deep bluish-green: the whole of these five changes occurring very near to the neutral point from $+\frac{1}{2}$ to $-\frac{1}{2}$ part per 100,000. There are also several intermediate tints, so that each part per million has its shade. By adding some phenolphthalein to this mixture a triple indicator is got which goes through all the seven colours of the spectrum in the correct order as it passes from alkalinity to acidity, viz., purple, indigo, green, citrine, yellow, salmon, and rose.

---

* The only other indicator of this class that is easily obtainable is alizarinyellow R, which changes from yellow to pink.

α-Naphtholphthalein is made by heating α-naphthol with phthalic acid and excess of dry $ZnCl_2$ to 120° C. for two hours. α-Naphthol can be got locally, and phthalic acid made by boiling naphthalene with *dilute* HNO_3 (under reflux) for several days, and taking the liquid to a small bulk. Since methylred (or the materials to make it) may not be available for some time, I also describe the colours given by mixtures in which substitutes for it are used (the other constituent being α-naphtholphthalein, for which there is no substitute): A. Neutral-red: range of mixture: violet-pink, salmon-pink, neutral tint (dirty brown), light green, and blue green. The neutral tint at the neutral point is interesting. B. Rosolic acid (or alizarine): range of mixture: dull yellow, salmon, rose, violet, indigo-blue (rose being neutral).

The ammonia and neutrality sections of this paper were read before the S.A. Association of Analytical Chemists in 1915, but have now been re-written and amplified.

Mr. Andrew F. Crosse *(Past-President)*: I desire to move a hearty vote of thanks to Dr. Moir as I have had a real treat, and I thank him very much for the very interesting explanation of these experiments, which I shall go through myself when I have time. I ordered from the local chemist some thymolphthalein, and I found the cost was excessive.

The President: I shall not discuss this paper myself now, because I think the methods given ought to be tried, before they can be discussed. These indicators, three of which you have heard of to-night, are quite new as far as most chemists are concerned; but I think that in the future we shall use a larger number of indicators than the three common ones at present in use, which, however, for some time to come, will probably hold the field. A good deal of work has been done in recent years on indicators, and researches have been carried out by Salm, Sörensen, and others with respect to their hydrogen ion concentration, and it is on tables such as they have constructed that practically the whole of what Dr. Moir has said this evening is based, a statement with which I think he will agree. These indicators can be arranged, and are arranged nowadays in order of merit, an excellent table having been drawn up by Dr. Moir himself. He has given us three this evening, and has put them to extremely good use. Whether those methods will be adopted generally is quite another matter, because, in practical chemistry, methods get standardised to a certain extent, and reform is slow. The method of determining ammonium in its salts seems quite excellent. However, I think this is the first time I have come across three indicators being used in one determination. There is a very well known method that was brought forward about the early eighties, as far as I remember, for determining the amount of NaOH, $NaHCO_3$ and Na_2CO_3 in mixtures of any two of these using two indicators, namely, methylorange and phenolphthalein. I am sure we are all very much indebted to Dr. Moir for this paper and for his demonstration of these indicators, and have therefore much pleasure in seconding the vote.

Dr. J. Moir *(Past-President)*: I have lately made some methyl red in small quantity, and am willing to supply the very small quantities which are required of this methyl red to members, who may care to try the experiment.

The President: With regard to methyl red, there was an abstract in our *Journal* of a paper read before the Edinburgh Section of the Society of Chemical Industry last March on its use as an indicator in determining the hardness of water, and I believe Mr. Whitby, after testing that method, was firmly convinced of its great utility.

Mr. A. Whitby *(Member of Council)*: It is, in my opinion, much superior to the Otto Hehner method of determining both the permanent and the temporary hardness of water.

THE ENCOURAGEMENT OF FIRST AID WORK ON THE MINES: SOME SUGGESTIONS BASED ON CROWN MINES EXPERIENCE.

By A. J. Brett.

(Printed in Journal, June, 1916).

REPLY TO DISCUSSION.

Mr. A. J. Brett: In reply to the discussion I have to thank your President and Members for the kind reception accorded to this paper. The first point made by your President is the necessity for keeping the offices of Hospital Orderly and Chief Ambulance Officer distinct; in this I am in entire agreement with him, and may state that it is our practice on the Crown Mines, not only in the case of the Chief Ambulance Officer, but in the case of the Sub-Ambulance Officers also, to pay their salary and their remuneration for ambulance work by means of separate cheques.

The suggestion that more might be done in the way of making bonuses, etc., more dependent on the actual work of men at accidents, I am afraid, would be very difficult to arrange in actual practice. Under such an arrangement in sections of the mine where accidents are few and far between, a knowledge of ambulance work would be at a discount, as many keen ambulance men who might be in these sections would possibly never have an opportunity of earning extra reward owing to their never having any calls on their services. If employees remained more or less stationary in their respective working places, this would have the effect of direct encouragement of First Aid work, where accidents were of most frequent occurrence. Unfortunately our experience at present is, that employees are by no means wedded to one working place and, therefore, I am afraid no satisfactory system could be devised on these lines. In practice we have to depend on reports from the Chief Ambulance Officer as to the efficiency of the aid rendered to him when accidents occur, and, as I said in my paper, it is most gratifying to find that he invariably has expressed himself as even more than satisfied.

Unfortunately, in actual working conditions it is almost invariably the case that no whole team can be got together at any one accident, owing to the scattered position of the working places and the distances that are likely to separate members of the same team, and therefore team work can really only be used for making any individual readily able to take his place, and do his part amongst any set of ambulance workers, whether he has been accustomed to work with them previously or not. In order, however, to try and improve on the present position, on the suggestion of Mr. Anderson, we are about to try the following method in one section of the mine to start with, in order to see if it can be carried out practically. On each level it is proposed that some type of board shall be erected at the station, on which the names of all men holding Ambulance Certificates shall be inscribed, and the names of their working places. If this can only be kept in order and up-to-date, it should be of great help to the Ambulance Officer, as he will at once see on arrival at any station what men he can depend on, and where he can lay his hands on them. it will also call attention to men holding such certificates.

For the above reasons I do not feel that the importance of the practice of team work by organising Ambulance Corps under Red Cross rules, as suggested by your President, is of anything like the importance on the Rand, that it is on coal mines, owing to the practical impossibility of the collecting of such teams for any particular accident. In coal mines the conditions are very different, and really call for such an organisation. At the same time your President's account of First Aid work in America, is of the greatest interest to anyone interested in this work.

In reply to Mr. Waites, I hope that since his first discussion on my paper, his experience, that interest in First Aid work underground is most noticeable by its absence, has been altered, for my experience shows that in the last six months there has been a very great awakening to the need of the encouragement of interest in this work, due largely, I think, to the good work of the Safety First Committee and your Society.

I have also been extremely sorry to gather from his remarks that he does not feel that the managements are as keen on the prevention of accidents as they should be. The prevention of accidents to-day does actually, I believe, take a foremost position in the minds of certainly the majority of mine managers along the Reef, if not in all of them. With regard to Mr. Waites' suggestion as to the possibility of making a knowledge of First Aid compulsory amongst all underground workers, at first sight it appears somewhat drastic, but on consideration it is really not so. After all, one never places, say, a battery engine or a compressor in the charge of a man unless one knows that if anything goes wrong he will know at least how to prevent the engine being wrecked, and, as a rule, one expects that he will be able to remedy any accident that occurs to it, unless it be a really serious one. Yet we have no hesitation to-day in placing the lives of, say, twenty human beings under the charge of a man who, in the majority of cases, if an accident happen to one of them, will in all probability have no idea of how to save his life, or even prevent his injury becoming a more serious one. When once you consider the matter in this light it does seem that compulsion is reasonable, and if it were to be combined with the excellent suggestion of Dr. Orenstein, that is to say, a very much simplified course of First Aid work, entirely with reference to mining, and excluding all matters not likely to be of any consequence in work underground, I believe it becomes feasible and should be pressed for. The First Aid course and Certificate as it stands to-day, I would then suggest, should still be made compulsory for officials. All interested men who had taken the compulsory course to obtain their blasting certificate, would still pass on to this course and certificate. With regard to more practical work than at present as advocated by Mr. Waites, I think competitions are the best means of encouraging this, together with a concession from the Mining Companies that a certain amount of company's time may be devoted underground every week to practice for such competitions. In that case I would strongly advocate that the competition for your Society's Shields and the proposed competition to be set on foot by the Safety First Committee, should be fixed at intervals of four months. That is to say, if the Society's Shields should be competed for in May, that would enable the mines to fix their own mine competition for September, and in that way the interest of all First Aid men would be kept alive throughout the year in practising for the competitions, and we should not have the present state of affairs, in which for a large portion of the year there are no competitions, and as a result during that time it is difficult to keep the necessary interest going.

In regard to Mr. Hildick Smith's suggestions, if compulsory First Aid work could be brought in, and I see no reason why it should not be on simplified lines, then would none of them be necessary. If such a desirable state of affairs cannot be arrived at, then I think there is a great deal to be said for all of them.

In conclusion, I may state that if my paper has served no other purpose, it has served to obtain the views of a practical underground worker, from which I hope further great progress may be made.

THE VALUATION OF MINES.

By Prof. R. A. Lehfeldt, D.Sc.

(Printed in Journal, September, 1916.)

Mr. E. M. Weston *(Member of Council)*: There is one question I should like to ask Prof. Lehfeldt, which should be of some interest Prof. Lehfeldt and Mr. Kotzé (the Government Mining Engineer) have, in dealing with the valuation of mines, used a phrase: "Let 'C' equal accrued capital." Now, by that is meant all the subscribed capital, plus compound interest. My impression was—I may be speaking quite in error—supposing that a mine was idle for five years before it started crushing and expended, say, a million pounds of subscribed capital; that they were rather inclined to take compound interest on that million pounds over the five years, and to call this sum 'C'. By taking the compound interest on a million pounds over the five years and calling that sum C accrued capital, if the interest is made big enough over five years, the mine can be made absolutely worthless before it commences work.

Take a practical case of a mine that is going to spend a million pounds over five years before it starts crushing. We might say this capital is subscribed in three different sums. I am, of course, talking quite roughly, but, say, £250,000 goes right away for the buildings and equipment on the mine; then development work and shaft sinking is started, and a sum over four years, we will say, of £20,000 a month is doled out. Then we come to the time just before crushing commences, and another £350,000 is spent on putting up the mill and further plant. This "C" then is a very much more complicated factor than either Mr. Kotzé or Prof. Lehfeldt apparently regard it. We certainly have this sum of £250,000 out at compound interest for five years, but the remainder of the capital, if subscribed, is earning interest during that time, and the interest on the £20,000 spent per month over four years, equals about the compound interest on the total sum, say, over two years, and the £350,000 that is put up just before milling starts practically only has one year's or half a year's interest to be debited against it. So I would like to ask the author if my impression is wrong, and whether this "C," accrued capital, does not involve rather more complicated factors than either he or Mr. Kotzé appear to give it? This is not put forward as a criticism, but as a question.

TESTING THE STRENGTHS OF EXPLOSIVES.

By J. A. Campbell (Member).

(Printed in Journal, October, 1916.)

The President: We have a communication from Mr. Campbell in connection with his paper.

Mr. J. A. Campbell *(Member):* We use only the standard size of Trauzl block, so I am unable to tell the effect of using longer blocks. Personally, I doubt if they offer any advantage. At one time we used plaster of Paris tamping, held down by an iron plate in a cast-iron frame, but the theoretically more efficient tamping so obtained gave no better results than ordinary sand tamping. The use of a longer block would raise the cost somewhat and increase the chance of faulty castings. High-grade pig lead is certainly easily obtained, but even if the impurities do not exceed 0·1% it is necessary to make each comparative test on lead cast from one melting.

Small lead blocks form a convenient method of testing detonators, as here the explosives tested are all of the same nature. To make these we press out a cylinder 64 mm. in diameter from the lead press and saw off the lengths required. The other measurements vary with the size of detonator to be tested.

No. 8.—Block 150 mm. long, drilled with hole 83 mm. × 7 mm. diameter.

No. 6.—Block 110 mm. long, drilled with hole 68 mm. × 7 mm. diameter.

No. 6D.—Block 110 mm. long, drilled with hole 68 mm. × 6 mm. diameter.

The temperature of explosion may be calculated from the figures obtained from an actual test with a special calorimeter, using the formula

$$t = \frac{Q}{c}$$

where t — temperature.
Q — heat disengaged by the decomposition.
c — specific heat of decomposition products.

It may be calculated without such experimental work, if there be known the equation representing the decomposition, the heats of formation of all the molecules present, and the specific heats of the resulting substances. The details of the calculation and necessary corrections will be found in Bulletin 15 of the United States Bureau of Mines.

NEUTRALIZATION EFFECT OF ASH ON ACID-SAND IN STOPE FILLING.

By Chris. Toombs *(Member of Council).*

(Printed in Journal, November, 1916.)

DISCUSSION.

Mr. F. W. Watson *(Member of Council):* In bringing forward some discussion on Mr. Toombs' paper, I must congratulate him on the ingenuity shown in an attempt to remove two blots on the landscape, sand dumps and ash heaps. That he can do so with mutual benefit to each is an advantage not lightly to be overlooked, though one is inclined to think that he is particularly favoured in this respect by the quality of the ash, or rather of the coal, in use.

The chief neutralizing agent in the ash is, according to the author, calcium carbonate, and this, he claims, neutralizes the free acid in the wet sand and decomposes the ferric sulphate, thereby removing the most harmful constituents of the sand dump. I cannot, however, congratulate him on his qualitative experiments which have led him to conclude that calcium carbonate will not eliminate all acid and acid producing substances. He finds that calcium carbonate has no action on ferrous sulphate in solution. I am confident that if his labours had been carried further, both experimentally and on a practical scale, he would have modified his opinion.

I have frequently tested mine waters,

which before treatment contained ferrous sulphate in considerable quantity. These waters had been treated underground with powdered limestone only, and this treatment had completely eliminated the ferrous sulphate. To verity this I carried out the following experiment:—

A sample of mine water was titrated with N/10 NaOH and N/10 $KMnO_4$; the values are shown below.

To one litre was added 0·5 gm. limestone, the mixture was stirred for three minutes and the permanganate value again taken.

The mixture was agitated and transferred from one beaker to another for five minutes, then it was allowed to stand with occasional transference from one vessel to another for four hours and finally allowed to stand overnight. The total reducing value towards permanganate is given as ferrous sulphate, no account being taken of other reducers which might possibly be present.

The following results were obtained:—

	Acidity to phenolphthalein (expressed as H_2SO_4) %	$FeSO_4$ (by permanganate) %
Original	0·035	0·027
After 3 minutes' stirring	—	0·024
After 3 minutes' stirring and 5 minutes' transference	0·023	0·021
After 1 hour occasional transfer	0·019	0·018
After 2 hours' occasional transfer	0·014	0·015
After 4 hours' occasional transfer	0·011	0·009
Overnight without further agitation	0·002	0·003

These figures show that the $FeSO_4$ has been practically eliminated from the water when atmospheric air had free access. It will also be noticed, that considerably more alkali is required to show reaction to phenolphthalein than would theoretically be required to precipitate the $FeSO_4$ as found by permanganate. I find this to be the case in solutions of pure ferrous sulphate, probably due to the ferrous hydrate carrying down combined fixed alkali with it.

If $CaCO_3$ had *absolutely* no action on $FeSO_4$ in solution, the first stage of the reaction would necessarily be the oxidation of ferrous to ferric sulphate and then precipitation of the latter by limestone. This I cannot think probable, especially in the absence of free acid, as ferrous sulphate is a fairly stable body, and a solution of this salt alone showed no change when given the same treatment as in the above experiment. The other explanation is that limestone reacts to a slight extent with the ferrous sulphate to form ferrous carbonate, which would be much more easily oxidized to the ferric state, and thus upset the chemical equilibrium of the solution, since one of the products of the original reaction would be removed. The reaction would thus go on till practically all the $FeSO_4$ was decomposed.

Dr. J. Moir *(Past-President)*: Mr. Toombs talks of ferrous carbonate being formed. Now is it not probable that it is ferrous bicarbonate that is formed, since CO_2 is present in excess from the action of free acid on carbonate of lime? It is well known also that solutions of ferrous bicarbonate are destroyed by aeration.

Mr. F. W. Watson *(Member of Council)*: Yes, I suppose that is so: Most of these waters trickle down from one stope to another; they go through sumps and everything else.

FLOTATION CONCENTRATION EXPERIMENTS ON A TRANSVAAL GOLD ORE.

By F. Wartenweiler (Member of Council.)

(Printed in Journal, November, 1916.)

Mr. H. R. Adam *(Member of Council)*: Mr. Wartenweiler's paper was exceedingly interesting, and as it evidently summarised the results of a considerable amount of work it seems a pity that the author did not give more details of individual tests, unsuccessful as well as successful. I think the statement that the slightly alkaline circuit gave the best results both from a commercial and metallurgical point of view should have some figures to support it. The advantages of lime for future cyaniding are of course obvious, but one would like to compare the flotation results obtained with acidified water and also the effect of heating.

Again, a great deal of analysis requires to be done if the fullest information is to be obtained. It is not sufficient to give the gold values of the products alone. Sulphur, and in this particular case arsenic, in concentrate and tailing would give useful information, also "insoluble matter" in the concentrate. These figures are required in order that the closeness of association of the gold with the "refractory" mineral or minerals may be arrived at. Having these figures, one may be able to decide whether to aim at very complete flotation of the gold with the sulphides, etc., possibly using more costly flotation methods to do so, or whether to regard removal of the "refractory" mineral with as little gold as possible as the prime object. The latter aim is, of course, more important when the extraction of the gold from the concentrate presents serious difficulties.

There seems to be a tendency to regard the nature of the oil or oils used as the all important thing in flotation. I doubt if it is really correct to speak of the "selective action" of the oil at all, since flotation can be carried out in some cases without the use of oil at all, however necessary the latter may be in practice. The selective agent for the sulphide minerals is gas in the form of small bubbles; perhaps the main function of the oil is to prevent the gas bubbles from coalescing and dropping their loads of sulphide.

Mr. Wartenweiler mentions that his experiments were carried out in a mechanically agitated type of machine. It is doubtful whether this is best in small scale work, when the fullest knowledge of the behaviour of the ore in flotation is required. In such machines there is always a considerable proportion of what may be called the "non-flotable" minerals in suspension. At the same time since this type of machine seems to be the most successful in practice, the information that the small model supplies may certainly be the most useful from the practical point of view.

Mr. H. A. White *(Past-President)*: I should just like to remark, although we have every reason to believe that flotation would not be successful on the Rand in removing gold to such an extent as that stated by the author, I think we ought to have on record any experiments of that nature that are made, and I think it would be in order if any member who has experiments of that kind would let us have them for publication.

The President: I hope members will accede to the request which has been made by Mr. White. If there are any members who have themselves or who know of any member who has made experiments on flotation, and they would kindly let us have these for record, I think it would serve a very useful purpose, more particularly as so very few experiments have, to our knowledge, been carried out here in this respect, one which on other fields assumes a very tremendous importance.

ORE TREATMENT AT THE FALCON MINE (RHODESIA).

By H. R. Adam, B.Sc. *(Member of Council)*

(Printed in Journal, November, 1916.)

Mr. J. A. Woodburn *(Associate)*: After reading through Mr. Adam's most interesting paper one's curiosity is only increased to know more of the details regarding the quality and character of the ore and the analysis and constituents of the furnace charge, with the analysis of the slag produced.

It is interesting to note that coal and coke are used in about equal quantities in the blast furnace, as this is rather an unusual practice. It is a good recommendation for Wankie coal, and one would like to know what total percentage of fuel was used per ton of charge.

In summing up the concentration of the ore the author says:—

> "The mill concentration plant recovers about 60% of the gold and 20% of the copper, while the flotation plant recovers

Sulphide Ore.	Tons Treated.	Value % Cu.	Tons Copper Cu.	Value dwt. Gold.	Ozs Gold.	% Extract Cu.	% Extract Gold.
Residue	8,900	0·3	26	1·5	667	8	19
Flotation Concentrate	2,000	8·0	160	5·0	500	46	14
Mill Concentrate ..	1,800	5·0	90	19·0	1710	26	50
Handsorted	1,300	5·5	71	9·0	585	20	17
Total Sulphide... ...	14,000	2·47	347	5·0	3462	100	100
Oxidised Ore Conc. ..	300	1·5	4·5	47·0	705	30	70
Tailings... ...	4,700	·22	10·5	1·2	295	70	30
Total Ox. Ore ...	5,000	·3	15·0	4·0	1000	100	100
Total Treated	19,000	1·9	362	4·7	4462		

20% of the gold and 70% of the copper—a total extraction of 80% gold and 90% of the copper by concentration."

I have worked out a probable monthly output from the figures given, and although the 60% and 20% extraction for the gold agrees fairly closely, the figures for copper extraction show more like 30% and 60% than 20% and 70%, as stated. The table given on the preceding page shows the tonnage treated in each department with values extracted in gold and copper.

Discarding the handsorted ore the extraction on the mill and flotation plants is as follows:—

	Tons Cu.	% Extraction.	Ozs. Gold	% Extraction.
Mill ...	90	32·5	1710	60
Flotation	160	58·	500	17
Residue..	26	9·5	667	23
		100·00		100·00

So that the percentage of extraction of the copper by the flotation process as stated by the author appears to be unduly high and the figure for the mill rather low.

The percentage extracted by the mill on the oxidised ore is 30% of the copper value, and 70% of the gold value, and it would appear strange if the extraction of the copper by the mill on sulphide ore should be less than on oxidized ore. As 20% of the copper value is taken out by hand-sorting on the coarse ore belt, and as the mill concentrate only recovers about 6% more, probably if the ore were crushed to $\frac{1}{4}$ in. or $\frac{3}{8}$ in. instead of $\frac{1}{8}$ in. in the first instance, a higher extraction might be obtained in the first concentration.

Without knowing the actual character of the average ore, it is difficult to know whether the fine crushing is necessitated by the finely disseminated copper value throughout the mass or is done in order to liberate the gold. If the extraction on the vanners previous to and after passing the tube mill, and the extraction on the blanket tables were known separately, some valuable information on this head would be gained. With so much fine concentrate one would have expected reverberatory furnaces for the smelting in place of the sintering plant and blast furnaces; and one wonders what especial reasons there were for installing this particular plant, as the concentrates from the flotation process must be very hard to deal with, and it is not stated what quantity of this concentrate is mixed with the sintered ore and hand-sorted ore in the blast furnace.

With regard to the converters, Mr. Adam says, "One converter is kept in operation and one as a stand-by," then adds later, "they do four blows" per day, but it is not quite clear if one converter does the four "blows," and whether it requires relining after the four blows, or if it is capable of further work with the one lining. He mentions that about 250 tons of picked oxidized ore are used every month in lining the converter, and it would be interesting to know what other material is used in the mixture for converter lining.

The tenor of the matte produced suggests a highly ferruginous charge to the furnace, and one wonders if the ore from the various concentrating processes are mixed in any particular proportion to obtain the most suitable charge, or if the ore bought in as custom ore is used as much for its fluxing properties as for its actual value in copper and gold.

In the proportion of charge sent to the sintering pots, in addition to the 450 tons of converter slag which is naturally ferruginous, there are also 250 to 300 tons of barren ironstone added, so that the concentrate itself is evidently silicious. I understand this fine ironstone is specially mined and transported some little distance for its fluxing properties. This point is very important, as at Messina the furnace charge was highly silicious, the iron content being very low and consequently a high grade matte was produced, not quite suitable for converter work, and the consumption of fuel in consequence was naturally high.

In a recent tender given out by the Messina Company for the purchase of custom ore, a reduction of 1s. per unit is allowed on smelting charges for all excess of iron and lime over insoluble on any ore purchased. In a ferruginous ore with little silica this excess might easily amount to 20%, which would mean a reduction in smelting charges of 20s. per ton. It is, therefore, of great importance that the analysis of any ore for furnace work should be given, as it is not improbable that at a central smelting plant near where coal and lime, fireclay and silica bricks, also basic materials for converter lining, are available at a low figure, the reduced cost of smelting ores from various mines, which tended to flux each other and thus save fuel, would more than counterbalance the cost of railage to the smelting works.

At the present moment it pays to transport 12% copper ore over 1,200 miles by rail to be reduced either to matte or blister copper in South Africa. The pre-war cost at Messina of smelting 10% copper middling from the mill with coal at 18s. per ton, to a 50% matte, was in the neighbourhood of 45s. per ton. This on a larger amount would have been nearer 35s. per ton. Taking the fuel consumption at 80%, the cost on this head alone would be about 14s. 6d., and if coal were only 6s. per ton then 10s. per ton would be saved for fuel costs on each ton smelted. Of course this reduction cannot be added to the other reduction allowed for excess iron and lime, as the fuel consumption, owing to better fluxing would probably be reduced to 40% or 50%, but still it indicates that considerable saving can be effected by suitable mixing of ores. The Falcon Mine, for instance, might be saved the cost of mining and transporting 300 tons per month of barren ironstone. It seems feasible, therefore, that if a steady supply of ore, matte or blister copper can be guaranteed for some years to come, both furnace and electrolytic refining might be adopted in South Africa with a good profit on all copper consumed locally and a fair profit on all copper exported. It has already been established that on a small scale smelting can be done in Africa, even in outlying districts, where fuel and other costs are high, at a cost very little more than in England, and it seems reasonable to expect that at places where fuel and other stores and material are more cheaply obtainable the cost of producing refined copper would work out at not more and probably less than in England. If it cost just the same, then there is no reason why the ingot copper should not be shipped and sold on the markets which now absorb the matte and blister copper, as freights should be fractionally less on the refined copper.

Of course, it must be remembered that however carefully a plant may be installed, there are practical difficulties to be overcome in starting any new industry in a new country, and it would take some time before the brands of copper produced established their reputation on the market, and the men at the works overcame all the little troubles incidental to a new plant. Then with electrolytic refining a large tonnage of copper is always locked up in the process. The cost due to these adverse circumstances should be dealt with as a capital cost, and this is where the Government might help in making an allowance on every ton produced or shipped for a few years until these adverse circumstances were overcome.

The benefit to the country in having the money spent on refining kept in the country and the stimulating effect on other industries should more than compensate for these initial probable losses.

The plant at the Falcon Mine, as described by Mr. Adam, is highly creditable to the engineers, who have faced the situation of dealing with a large rather low-grade copper and gold property, and the recent high price of the metal must have helped to pay for the initial extra costs incidental to a large new plant. It shows what can be done even where skilled labour has to be imported from oversea, and should stimulate effort in carrying out the smelting process to its final conclusion. Smelting and refining charges have risen considerably in England during the past two years, and these charges are likely to remain high for some time to come, owing to the increased cost of labour and fuel, so that the opportunity of competing with these high charges is one that should not be lost sight of.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Potash in Lake Muds.—"Potash in surprisingly large proportions is present in the brines and muds of the Salduro marsh, a sink in the Salt Lake desert, about 60 miles west of the south-west edge of Great Salt lake. From the clays underlying the salt body which covers the marsh the U.S. Geological Survey collected samples at depths of 8 ft. to 12 ft., in which the dissolved salts were found to contain from 2% to about 3½% of potash, and 2¼% was found in the soluble salts at a depth of about 4 ft. Of the dissolved salts contained in the brines occupying the spaces between the salt crystals in the crust overlying these muds 3% to 4% was found to be potash.

Singularly enough the salt crust left at the surface of the desert through the evaporation of the brines contains little more than a trace of potash, most of the potash being confined to the brines and to the muds underlying the salt crust. According to analyses made, the brines and muds contain considerable magnesium chloride, as well as chlorides of potassium and sodium, and so are somewhat similar in composition to the deposits from which potash is manufactured in Germany."—*Mining and Engineering World*, May 20, 1916, p. 958. (H. R. A.)

THE TIME REACTION IN THE NEUTRALIZATION OF CARBONIC ACID AND THE DISSOCIATION CONSTANT OF THE ACID.—"The reaction $OH^1+CO_2 \rightarrow HCO^1$ is the determining factor of the reaction velocity of the neutralization of carbonic acid. Measurements with the pure acid showed that no alteration of conductivity with the time occurred, hence the above reaction is apparently so accelerated by the hydrogen ions that the time reaction is no longer measurable. A similar catalytic action of hydrogen ions occurs in the conversion of γ-hydroxy fatty acids into lactones. In the neutralization of carbonic acid the reaction velocity is proportional to the concentration of the acid and base inversely proportional to that of the bicarbonate. The mean value at 0° C. is $k = 0{\cdot}043$. By means of the 'residual current' the concentration of the undissociated molecule H_2CO_3 was determined, whence the dissociation constant

$$k = \frac{[H]\times[HCO_3]}{[H_2CO_3]}$$

was found to be $7{\cdot}12\times10^{-4}$, a value which is greater than that of acetic acid."—L. PUSCH.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 835. (J. A. W.)

PROPERTIES OF SODA LIME.—"Many reactions which do not take place with sodium or potassium hydroxide or lime, or take place only at high temperatures, occur at the ordinary temperature, and sometimes violently when soda-lime is employed. Further, soda-lime constitutes the most efficient agent to combat poisonous, irritating, or tear-producing gases, since it readily absorbs chlorine, bromine, halogen hydracids, carbon dioxide, sulphur dioxide, carbonyl chloride, cyanogen, hydrogen cyanide, cyanogen chloride, bromide and iodide, sulphur chloride, thionyl chloride, nitrosyl chloride, nitrogen peroxide, hydrogen arsenide, antimonide, sulphide, and selenide, mercaptans, thiocyanic acid, indole, scatole, aldehydes, chlorocarbonic esters, aromatic chloro- and bromo-derivatives with the halogen in the side-chain, ethyl bromoacetate and chloro-acetoacetate, chloroacetone, bromoacetophenone, acetic anhydride, etc. The soda-lime acts far more energetically when recently prepared and stored in a hermetically sealed vessel. 100 gm. of soda-lime in fine granules will absorb 1500—2250 cc. of carbonyl chloride. Hydrogen sulphide is readily absorbed by soda-lime, and the reaction is attended with the development of a very considerable amount of heat; when the current of gas is mixed with air the soda-lime becomes incandescent, whilst replacement of the air by oxygen results in a violent explosion. This incandescence is observed only with freshly-prepared soda lime, which should consist of granules 1—3 mm. in diameter, 100 gm. of soda lime absorbs 35 litres of hydrogen sulphide. Soda-lime also absorbs hydrogen selenide, which produces rapid and intense irritation of the mucous membrane of the nose and is capable of paralysing the sense of smell for some hours or even days. Sulphur dioxide is absorbed by soda-lime, rapidly at first and subsequently more slowly, 26 litres being taken up by 100 gm. The mixture of hydrogen chloride, nitrosyl and nitroxyl chlorides, and chlorine obtained from *aqua regia* is also rapidly absorbed, and the same is the case at first with cyanogen, of which more than 6 litres are absorbed per 100 gm.; the employment of soda-lime to retain the cyanogen emitted from blast-furnaces is suggested. Carbon monoxide at the ordinary temperature is absorbed but slightly or not at all. In presence of soda-lime, ammonia causes at the ordinary temperature reactions which otherwise occur only at high temperatures. Hydrogen phosphide, prepared by passing hydrogen into a flask containing 45—50% potassium hydroxide solution, and a few pieces of phosphorus, is spontaneously inflammable, but loses this property when passed through soda-lime; the latter also absorbs phosphorus vapour. Soda-lime may be used to purify the hydrogen obtained by the action of acid on iron or zinc, but it will not remove hydrogen phosphide, which is detected by the green colour of the flame. Soda-lime absorbs many of the impurities of coal-gas and takes away its fœtid odour; similar purification and deodorisation occur with acetylene, which is not absorbed by soda-lime."—I. GUARESCHI, Atti. R. Accad. Sci. Torino, 1916 *Journal of the Society of Chemical Industry*, Aug 15, 1916, p. 835. (A. W.)

PORTLAND CEMENT.—"The author attributes the superiority of Portland cement to the presence of 35% of tricalcium silicate. Study of the ternary system $CaO—Al_2O_3—SiO_2$ indicates that the formation of the constituents of Portland cement is as follows: The calcium carbonate is first converted into free lime which then unites with the clay forming $5CaO,3Al_2O_3$ and $2CaO.SiO_2$; these subsequently unite with more lime and form $3CaO.Al_2O_3$ and $3CaO,SiO_2$ the reaction being facilitated by the formation of a flux at 1335° C. —the eutectic temperature of $2CaO,SiO_2$, $5CaO.3Al_2O_3$, and $3CaO,Al_2O_3$. As the temperature rises above 1335° C. any free lime present reacts with the $2CaO,SiO_2$ forming $3CaO,SiO_2$. It is not necessary to continue the heating to complete fusion, a temperature of 1650° C. being usually sufficient for commercial materials. At this temperature the mass consists of 30% molten and 70% solid material, but on cooling the clinker is completely crystalline, and contains approximately $3CaO,SiO_2$ 45%, $2CaO,SiO_2$ 35%, and $3CaO.Al_2O_3$ 20%. The percentage of $3CaO.SiO_2$ is the chief factor in determining the value of a Portland cement. This is the last substance to be formed during the heating of the materials and under ordinary conditions 35% of it is the maximum obtained. The proportion is regulated by the temperature and duration of the heating, the amount of fluxing agents ($FeO.MgO.Na_2O$, etc.) present, and the size of the particles. A larger proportion of free lime than that normally used would produce a higher percentage of $3CaO,SiO_2$ if the temperature and duration of heating were sufficient, but free lime in the finished cement must be avoided as it causes loss of strength and facilitates disintegration. As an alternative to a higher burning temperature (which is impracticable commercially), a material richer in fluxes may be used, so as to bring about the reaction $CaO+2CaO.SiO_2=3CaO.SiO_2$ below 1650° C. instead of at the much higher temperature required with the usual materials. It is proposed to study other systems such as $CaO—Fe_2O_3—SiO_2$, to ascertain whether the replacement of Al_2O_3 by other oxides will effect this reduction in temperature and increase the rate of formation of $3CaO.SiO_2$." G. A. Rankin.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 842. (J. A. W.)

Froths Formed by Flotation Oils.—"The froth produced by any given oil differs with the machine in which it is made. It is extremely important that the oil shall be well mixed with the pulp before flotation is attempted, the best way being to add the oils in the mills during grinding. When not thoroughly mixed, the oils prevent rather than produce froth, and for this reason extraneous oils such as cup greases and lubricating oils cause trouble in the flotation machines. *Pine oil*, as a general rule, is a rather poor mineral collector but a good frothing agent: it is, however, a good mineral collector on ores carrying chalcocite and on some zinc ores: its action as a mineral collector can often be increased by the addition of acid, and sometimes by the addition of caustic alkali: the froth is brittle, and the bubbles produced are small. *Coal tar* is a poor frothing agent but a good mineral collector, and is seldom used without mixing with pine oil or other frothing agent: it works well with many different minerals: it is difficult to mix with the pulp, and, in general, requires grinding: the bubbles are brittle. *Coal tar creosote* is used chiefly to dilute the cheaper coal-tar oil, and for this purpose is very good; it is easy to mix; and works best on copper-bearing ores. The bubbles are very tough and tend to be rather large. *Wood creosote* resembles coal-tar creosote in some characteristics: it works best on zinc ores, and is often used to dilute coal-tar in the treeatment of these ores. The bubbles are even tougher than those yielded by coal-tar creosote. *Cresol* is used in small proportions in mixtures with coal-tar. *Fuel-oil, pine-tar oil, oleic acid, and eucalyptus oil* are often used in mixtures. The best mixture can only be determined by trial, preferably on the large scale. In general, the best froth is one in which the bubbles are of medium size and rather tough."—W. A. Mueller.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 848. (A. W.)

Use of Oils in Flotation.—"The functions of a flotation oil are to reduce the surface tension of the liquid so that a more permanent gas bubble may be formed, and to oil the mineral particles preferentially. The oils used may be divided into two groups:—(1) those which serve to make frothing possible by reducing the surface tension of water, and (2) those which provide a non-wet film on the surface of the mineral particle. The best mixtures of oils to accomplish these results can only be determined by trial in each special case. The author describes investigations made to ascertain the best mixtures of oils for certain ores, and gives examples of actual practice."—H. A. Megraw.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 848. (A. W.)

Iceland Moss as a Protective Colloid.—"By using an extract of Iceland moss as protective colloid, solid colloids containing high percentages of gold can be prepared, and so long as the gold content does not exceed 82%, these can be converted completely into the sol condition by means of water. Paal obtained reversible gold colloids containing up to 93·41% Au, by using sodium lysalbinate as protective colloid, but in this case it is necessary to use an alkali solution to convert the solid colloid into the sol condition. Water sterilized by addition of chloroform was used in preparing the extract of Iceland moss, and it was observed incidentally that water saturated with chloroform had a stabilising effect on some unprotected inorganic colloids. A protected colloidal gold preparation containing 42% Au showed no indications of ageing even after keeping for one month at 25° C. Colloidal palladium was prepared by reduction of palladous chloride by hydrazine hydrate in presence of an extract of Iceland moss; the limit of complete reversibility was attained at 70% Pd."—A. Gutbier, J. Huber, E. Kuhn, and J. Krauter.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 848. (J. A. W.)

Determination of Phosphoric Acid by the Citro-Uranium Method.—"The citrate-soluble phosphoric acid in phosphatic fertilisers may be estimated by precipitating the phosphoric acid as ammonium magnesium phosphate under the conditions described by Popp, dissolving this precipitate in hot acetic acid, and titrating the solution with standardised uranium acetate solution, using potassium ferrocyanide as the indicator. For the estimation of total phosphoric acid in fertilisers containing much silica, the interfering action of the latter may be eliminated by boiling 10 gm. of the sample with 5 gm. of ferrous sulphate and filtering the mixture. Results of numerous estimations of phosphoric acid in a variety of fertilisers are recorded, showing that the results obtained by the method are trustworthy." D. Crispo and R. W. Tuinzing.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 857. (J. A. W.)

Determination of Aluminium as Oxide.—"A detailed study of all the factors concerned in the estimation of aluminium as oxide has led to the recommendation of the following method of procedure. The solution containing the aluminium salt (in amount equivalent to 0·10 gm. alumina) is treated with ammonium chloride in the proportion of at least 5 gm. to 200 cc. of solution, a few drops of a 0·2% alcoholic solution of methyl red are added, and the liquid is heated until it just boils. Dilute ammonia solution is introduced drop by drop until the solution becomes yellow, whereupon the liquid is boiled for 1—2 minutes and then filtered immediately. The precipitate is washed thoroughly with a hot 2% solution of ammonium chloride or nitrate. A platinum crucible is used for the ignition, and after the carbon has been burnt off, it is heated with a blast flame for 5 minutes, then covered immediately and cooled in a desiccator. A second heating for a like period is recommended. The weighings must be performed with the crucible well covered. Experiments made with a hydrogen electrode and with various indicators showed that aluminium is precipitated completely by ammonia when the hydrogen ion concentration is reduced to $10^{-6.5}$ - $10^{-7.5}$, and that this point is given approximately by the colour changes of methyl red and of rosolic acid. The presence of ammonium chloride during the precipitation reduces the solubility of the hydroxide and tends to coagulate it. The addition of glycerol or of tannic acid is not recommended, but macerated filter paper aids filtration, especially of large amounts of precipitate. The conditions of precipitation are suitable for the co-precipitation of ferric iron, and for the separation of both metals from barium, strontium, calcium, and magnesium. The addition of a little ammonia to the wash-water is not advised. The covering of the crucible during drying and weighing is necessary, as alumina is decidedly hygroscopic: 0·10 gm. of ignited material absorbed 1 mgm. of moisture in 5 minutes. When the amount of oxide does not exceed 0·1—0·2 gm., heating with the blast flame for longer than 5—10 minutes is unnecessary; and the presence of ammonium chloride during ignition causes no appreciable loss of material."—W. Blum, *J. Amer. Chem. Soc.*, 1916, *38*, 1282-1287.—*Journal of the Society of Chemical Industry*, Aug. 31, 1916, p. 908. (A. W.)

Qualitative Separation of Tellurium, Arsenic Iron, Thallium, Zirconium and Titanium.—"The solution containing tellurium and arsenic in presence of dilute hydrochloric acid, is treated with sodium sulphite and potassium iodide to precipitate the tellurium (Noyes and Bray, *J. Amer. Chem. Soc.*, 1907, *29*, 137). The filtrate is boiled to remove sulphur dioxide, treated with hydrogen peroxide to decompose the iodide, and then boiled to remove iodine. Thereupon the liquid is made alkaline with caustic soda, and more peroxide added to convert the arsenic into arsenate. After acidifying, the arsenate is precipitated by addition of ammonia and magnesium chloride mixture. The filtrate from the arsenic precipitate may be tested for molybdenum by treatment with potassium thiocyanate and zinc in hydrochloric acid solution.

To separate iron, thallium, zirconium, and titanium, the precipitated hydroxides are dissolved in a minimum amount of sulphuric acid, and hydrogen peroxide is added: a red coloration indicates titanium. After rendering slightly alkaline with caustic soda, adding sodium phosphate, and then acidifying with sulphuric acid containing hydrogen peroxide (to keep the titanium oxidised), zirconium is precipitated as phosphate ($ZrOHPO_4$). The filtrate from this precipitate is then treated with caustic soda, whereby iron and thallium are removed, and the liquid is again filtered. The filtrate is acidified with sulphuric acid, and the titanium then precipitated as phosphate ($TiOHPO_4$) by adding sodium sulphite and a little more sodium phosphate. The mixed iron and thallium hydroxides or phosphates are dissolved in sulphuric acid, sodium sulphite is added, followed by potassium iodide, which precipitates thallous iodide; the filtrate from the latter is boiled to remove sulphur dioxide, treated with hydrogen peroxide to remove iodine and to oxidise the iron, and the latter is then identified with potassium thiocyanate."—P. E. Browning, G. S. Simpson and L. E. Porter.—*Journal of the Society of Chemical Industry*, Sept. 15, 1916, p. 946. (A. W.)

Detection of Free Chlorine in Town Water Supplies.—"Very minute traces of free chlorine can be detected and the amount roughly estimated by the addition of a few drops of a solution of hexamethyltri *p*-aminotriphenylmethane; a violet coloration, which varies in intensity according to the amount of free chlorine present, is immediately formed. The reagent is prepared by digesting 1 part of the organic compound in about 10 parts of diluted hydrochloric acid (1 : 1), and making up to 100 parts with distilled water. As an opalescence is produced with some waters, it is advisable to add a little formic or acetic acid, to prevent its appearance. The reagent is stable towards water, reacts extremely slowly with nitrites, and is quite unaffected by hydrogen peroxide. With its aid, 3 parts of chlorine in 100 millions can be detected: the limit of the starch-iodide reagent is 1 part in 10 millions."—G. A. Le Roy.—*Journal of the Society of Chemical Industry*, Sept. 30, 1916, p. 976. (J. A. W.)

METALLURGY.

Cyanide Eczema or Rash.—"For cyanide eczema use equal parts by weight of calomel and bismuth subnitrate, and apply locally. It will give immediate relief and will dry up the sores in two or three days.

Other prescriptions are as follows:

Add 3 oz. of camphor to 1 pint of olive oil, and dissolve by slow heat. This occasions some pain when first applied, but will soon afford relief.

In mild cases, the following will be beneficial: zinc oxide ½ oz., zinc carbonate 30 gr., glycerin ½ oz., lime water to make up ½ pint.

For sores which do not heal use: pure lard 5 oz., olive oil 5 oz., white wax 2½ oz., spermaceti 2½ oz., powdered gum benzoin 12 oz."—Extract from "Metallurgists' and Chemists' Handbook," by Donald M. Liddell, p. 586, 1916. (W. A. C.)

Testing Fire-Bricks.—"The selection of a suitable refractory calls for a study (1) of the temperatures involved, and (2) of the nature of the hot material and resulting slag to which the refractory will be exposed. In a paper describing methods of testing designed to simulate as far as possible working conditions in iron and steel manufacture, read before the American Society for Testing Materials by Messrs. C. E. Nesbit and M. L. Bell, it is pointed out that two general conclusions have been derived from a review of the use of refractories in iron and steel plants: (1) The life of a furnace is determined by the life of its brickwork, and (2) different furnaces demand different physical properties in the bricks used. The authors then detail the tests they conducted.

Impact Test.—After considering rattler and similar tests it was decided to employ a steel ball 2½ in. diameter, dropped from various heights on a brick heated to the working temperature. A brick heated to 260° C. and thus tested was 20% weaker than a brick of the same brand tested at 20° C., and 40% weaker when tested at 540° C.

Abrasion Test. Abrasion tests were conducted, with the brick cold, by means of an emery wheel. The tests showed that bricks are not the same at both ends, there sometimes being 10 to 20 times the abrasion at one end as at the other.

Spalling Tests.—Spalling usually results from thermal changes accompanied by mechanical pinching. The test for spalling finally decided upon consisted in placing the brick in the wall of the furnace, exposing only one end and subjecting it to a temperature of 1,350° C. for one hour. It was then cooled in water, which was found to be three times as effective as cooling in air. The amount of spalling is reported as the percentage loss in weight.

Slagging Tests.—Slag tests were made by drilling a cavity in the brick and filling it with slag. To measure the slag penetration the brick was cut so as to expose a cross-section of the slag pocket, and the area of the slag penetration exposed was measured by a planimeter.

Compression Test.—To determine the ability of bricks to stand up under loads when highly heated, a modified Brinell ball test was applied by heating a brick to 1,350° C., removing it from the furnace and forcing a 2½ in. steel ball into it under a pressure of 1,600 lb.

Results of Tests.—It was found that the firebricks tended to group themselves according to density. Other qualities being the same, the bricks of high density had, as a rule, the best qualities—viz., least abrasion, good resistance to slag and least compression. Spalling was slightly increased, but not dangerously so, if the bricks were not overburned. Specific gravity, obtained by weighing and measuring the brick, was the measure of density. Various makes of bricks had characteritic values for apparent specific gravity and the method of manufacture influenced the density.

To determine the effect of pressure and moisture in producing a dense brick a standard fire-clay mixture was used in which the moisture varied from 4% to 12%. All bricks were pressed at 2,000 lb. per sq. in. and then burned in a regular kiln. Power-pressing a brick during manufacture up to 1,500 lb. per sq. in. had been found to materially improve the quality of most firebricks. Beyond that figure little improvement was made. The following table compared tests on a high-pressure, low-moisture brick and a hand-made, re-pressed, ordinary-moisture brick, both being of the same mixture.

Comparative Tests of High-Pressure, Low-Moisture, Brick and Hand-Made, Re-pressed, Ordinary-Moisture Brick.

Properties considered—		Kind of brick — Pressure of 1,500 lbs. per sq. in. moisture, 7 per cent.	Kind of brick — Hand-made, repressed, ordinary moisture.
Compression at 1,350° C. depth of impression, inch ..		0·29	0·55
Expansion per foot of length at 1,350° C., inch		0·062	0·059
Impact of 260° C., height of drop, inches		45	28
Abrasion at 1,350° C. in five minute, inch		0·02	0·04
Spalling loss, per cent. ...		9·4	10·6
Slag penetration, sq. in.	Blast furnace slag ...	0·27	0·56
	Heat. furnace slag ...	0·26	0·67

The methods above described have been developed mainly with reference to the brick used in iron and steel plants."—*Iron and Coal Trades' Review*, Aug. 25, 1916, p. 225. (E. M. W.)

IMPURITIES IN COMMERCIAL TIN.—"According to the rules of the London Metal Exchange, tin is merchantable as standard tin only when the warrant is accompanied by analysis certifying that the metal contains either 99·00% or 99·75% of pure tin, according to whether the quality is that of a common tin or refined tin, and also that it is of the correct physical condition.

Straits, Australian, English Refined, Banka and Billiton fall within the highest class, namely, refined tin. The Chinese tins are 'off-grade,' carrying considerable lead, and the German tins, resulting from the smelting of Bolivian concentrates, are very foul. Off-grade tins are sold on the basis of a sliding scale for tin content. The worst of them will run over 90% tin, while the high-grade tins will run 99·8% to 99·9%. The only tests required for good merchantable tin aside from its origin are that it shall run at least 99·75% tin, and that a bar when nicked and bent double shall not crack.

The consumer has generally met the situation in which he finds himself by buying a first-class brand, analysing it when he gets it, and then sorting the lots by analysis for certain uses. It is of doubtful value to give here a long list of analyses of different brands, but a rough idea of the various grades will illustrate the situation.

TABLE *I.—Analyses of Different Brands of Tin—All Values in Per Cent.*

Elements.	Straits, Banka Billiton.	Australian.	English Common.	English Refined.	Chinese.	Bolivian.
Tin .	99·80-99·95	99·75-99·90	99·2	99·9	95-99	93
Antimony	0·02	0·04	0·25	0·04	0·02-0·40	4·0
Arsenic ..	0·04	0·06	0·06	0·05	0·06	0·2
Bismuth ..	None	0·003	0·06	0·001	0·01	0·1
Copper ..	0·01	0·04	0·08	0·015	0·09	0·5
Iron	0·03	0·03	0·004	0·002	0·15	0·02
Lead	0·02	0·04	0·36	0·01	0·3-4·0	2·7
Zinc .	0·03	None	0·006	0·01	None	0·03

The impurities in tin may cause trouble by poisoning, as in the case of pipe and tin cans; by impairing fluidity, causing an excessive consumption of tin used for coating, or making solder hard to apply; by fouling an alloy and spoiling its appearance; by impairing the ductility of alloys which have to be worked, such as bronze or Britannia metal; by causing local galvanic action and possibly 'tin pest'; and by affecting the melting point of fusible alloys.

One of the tinplate manufacturers states that lead makes a mottled finish, iron causes rough surface and impairs fluidity, and arsenic and zinc tend to form poisonous salts. They suggest maximum allowable percentages as follows:—Lead, 0·04%; copper, 0·02%; iron, 0·05%; arsenic, 0·05%; antimony, 0·02%; zinc, 0·05%."—*Iron and Coal Trades' Review*, July 28, 1916, p. 97. (E. M. W.)

FLOTATION OF FLOUR GOLD.—"An ore containing Au 0·3 oz., Ag 2·5 oz. per ton, Pb 5, Zn 8·5, Fe 2·5 and Cu 0·5%, could not be treated with economic success by gravitation concentration, but was successfully dealt with by floating the slime and treating the coarse portion by gravity and electrostatic separation. The froth concentrates, obtained without the use of acids or heat, were washed with water to a Wilfley table which effected a perfect separation of the relatively coarse lead and zinc. The gold, which was in an extremely fine state of division, appeared very largely in the first riffles of the table, the saving of gold amounting to about 85%." R. W. SMITH.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 846. (J. A. W.)

CHEMICAL ASSAY OF TIN ORES.—"The percentage of tin in the battery pulp and primary and secondary tailings from a highly pyritic tin-stone was determined by vanning (after digestion with acid) and fusion with cyanide, and also by the Pearce Low wet method treatment with *aqua* *regia*, fusion with sodium hydroxide, reduction with nickel and hydrochloric acid, and titration with iodine solution). With the battery pulp, the average results by vanning were about 50% below those found by the chemical assay. Vanning the primary tailings gave a recovery of about 14·5%, but when 10 gm. (instead of 100 gm.) samples were taken, 50% of the tin content was recovered. With the secondary tailings, vanning gave 33% of the tin value as shown by the wet assay, but 50% when 10 gm. portions were used. In addition to being quick, the vanning method is valuable because it gives results which correspond roughly to those obtained in actual milling practice. Vanning for 15 minutes without acid treatment and in dirty water, showed that a slime table might be expected to save about 40% of the tin content of the primary tailings and about 48% of that of the secondary tailings. A Cornish round table actually operating on the latter made an average saving of 50%. The wet assay method has not been found to give too high results. The substitution of iron (horseshoe) nails for nickel in the reduction works well provided that two nails only are used."—A. M. MATHESON.—*Journal of the Society of Chemical Industry*, Aug. 15, 1916, p. 847. (J. A. W.)

CHEMICAL METHODS OF TIN EXTRACTION.—"Chlorides of tin have quite recently, as well as in the past, formed a favourite subject for numerous proposals for the extraction of metallic tin from cassiterite. Some inventors have had recourse to previous reduction of the tin to metallic tin, and the subsequent treatment of the reduced mass with hydrochloric and other acids. The stannous chloride thus produced must necessarily be contaminated with other elements, which makes the subsequent treatment difficult and complicated. Fractional precipitation by means of various reagents has been suggested and tried, a notable example being the process of the late J. W. Chenhall, who succeeded in the laboratory and on a semi-commercial scale in separating the various constituents of a complex Cornish ore, containing wolfram, copper, arsenic, etc., by leaching with sulphuric and hydrochloric acids after roasting and reducing the ore with coal dust.

Considerable attention has been attracted by a process evolved by Arthur Richards, which essentially consists in mixing the ore with salt and carbonaceous matter and submitting the mixture to a red heat, with the result that the tin is volatilized as a chloride of tin. I understand that this method was tried on a semi-commercial scale, and that the experiments are still being conducted by Mr. Richards. I am informed that with certain Cornish ores the treatment leaves very little tin in the residue. Mr. Richards has been good enough to give me the following figures: The charge assayed at 35 lb Sn per ton and the residue after treatment 1·25 lb. The volatilized product, presumably a very basic oxychloride, contained 65% of Sn, which after calcination and washing with HCl was brought up to 74% of Sn. That it did not reach the theoretical amount of Sn (78·6%) is probably owing to some of the dust being carried over mechanically. This process is certainly worthy of careful attention, as such a reducing chloridizing roast as applied to tin ores seems to offer a reasonable solution of the problem. We have, however, to consider that simultaneously with the tin, iron chloride would presumably be volatilized. Unfortunately also chloride of tin, owing to the high specific gravity of its vapour, will not travel far and is difficult of condensation if diluted with other gases. Furthermore, it must be borne in mind that an operation of this sort, in order to be successful, would probably have to be carried out in a muffled furnace or retort. The construction of such a furnace might offer considerable difficulties, owing to the probable necessity of stirring, and the question of high fuel consumption is serious when dealing with 1% or 2% tin ores. Mr. Richards has, however, informed me that he is experimenting in another direction, which may obviate the use of a muffled furnace entirely; in fact he maintains that the chloride which is driven off is at once converted into oxide by the action of light and air. Personally I can hardly agree with this, although it is quite possible that he has to deal with an extremely basic oxychloride of tin. As I have shown above, $SnCl_4$ is easily decomposed by air and water. Assuming that all these difficulties could be overcome, it should be quite easy to smelt the oxychloride or oxide ultimately produced to metallic tin, which, indeed, has already been done with a small quantity produced by the Richards' process.

Various other ideas present themselves to the inventor, assuming that the tin could be obtained as bi-chloride in solution; and this should not be difficult even if an oxychloride were formed, as it would only require the addition of some hydrochloric acid to render it soluble. The chloride of tin could then be precipitated by means of a more electro-positive metal, as, for instance, zinc or aluminium, but the cost of doing this would be considerable if not prohibitive. Then there is certainly the possibility of producing a pure oxide of tin from these solutions, which would be valuable for the purpose of making enamels, but the SnO_2 used for such purposes has to be practically chemically pure. Another method of recovering the tin from the stannic chloride solutions might be an electrolytic one, as it is not very difficult to deposit tin successfully from a chloride solution. This was done commercially for some time by Bergsoe, in Denmark, not in connection, however, with tin ores, but for the purpose of recovering tin from scrap. Naturally in such a process the chlorine given off at the anodes converts the $SnCl_2$ into $SnCl_4$, and this latter compound was employed by Bergsoe for dissolving the tin from scrap, regenerating $SnCl_2$ and thus making a cyclic operation. A process on these lines has recently been tried in connection with tin ores, but the publication of results is not permitted."—O. J. STANNARD.—*Mining Magazine*, July, 1916, p. 17. (E. M. W.)

ELECTRIC FURNACES AT SALT LAKE CITY.—"The Utah Iron & Steel Co., Salt Lake City, Utah, is considering the installation of electric furnaces chiefly for converting the scrap material available in that district into soft steel which may be rolled in its mills at Middale, near Salt Lake City. It is considering also the possibility of utilising local ores for the manufacture of ferro-tungsten and ferro-chrome. It may instal a furnace of as large as 12 tons' or 15 tons' capacity. The interests controlling the Utah Iron and Steel Co. also own the American Foundry and Machine Co., Salt Lake City, which is expanding its foundry business, and in that connection is shortly to instal a 3-ton Rennerfelt electric furnace. Low-cost electricity and an abundance of scrap material make the electric furnace an attractive proposition against local high cost of suitable coke and high-cost pig iron."—*Mining and Engineering World*, July 29, 1916, p. 192. (H. R. A.)

Electrolytic Zinc.—"The first of five sections, composing the new zinc refinery of the Anaconda Copper Mining Co. at Great Falls, Montana, was placed in operation on 11th September. The first stripping of the plates netted 25 tons of zinc that was sent to furnaces at Anaconda for transforming into the commercial article. The two new 50 ton furnaces that are to handle the output at Great Falls are being constructed, and are intended to be ready for operation about 1st October. By that time it was also expected that two additional units would be operating at the refinery, and by 1st November the entire plant, with a capacity of 5,000,000 lb. to 6,000,000 lb. of high-grade zinc per month, should be in operation. The first week's trial of the new plant proved most satisfactory. The zinc is brought in concentrates from the new concentrator at Anaconda. On arrival at Great Falls it is taken first to the roaster, where it is changed into calcines. This fine powder carries, in addition to zinc, copper, lead, silver and gold. It is next distributed to leaching vats having a depth of 20 ft. and a diameter of 10 ft. In these it is agitated in acid solution by compressed air forced in from below. After agitation the pulp passes into Dorr thickeners, where the lighter solution containing most of the zinc is drawn off and filtered, the pregnant solution being pumped into storage vats in the refinery proper, and sent from there to the electrolytic vats. These are arranged end to end with six vats in each battery, the solution cascading from vat to vat. Each vat is 5 ft. long, 3 ft. wide and 3 ft. deep, and contains 28 lead anodes and 27 cathodes consisting of aluminium plates, upon which the zinc forms. The zinc is 99·9% pure. Ground for the new plant was broken on 1st January, 1915, of this year, and close on $3,000,000 has been expended in the construction and equipment of this department. The aluminium cathodes for the electrolytic vats alone represent an investment of nearly $500,000. Each one contains 14 lb. of aluminium and 16 lb. of copper, and there are 20,000 of these in the five sections of the new plant. The copper metal for each cathode is worth between $4 and $5. In addition there is the expense of manufacture. The plant will use 33,000 h.p. when it is operating at capacity. This power will come from the Rainbow and Big Falls plant of the Montana Power Co., situated within 10 miles of the new refinery. The concentrator at Anaconda is completed, and there will be no lack of zinc concentrates for the new refinery as soon as the additional units are put into operation. By 1st November it was estimated that fully 2,000 tons of zinc ores per day would be used for this new department."—*Indian Engineering*, Jan. 13, 1917, p. 25. (J. A. W.)

Electrolytic Refining of Copper.—"The analysis of anodes of blister copper is given as: Cu, 99·25%; Ag, 70·0 oz. per ton; Au, 0·25 oz. per ton; As, 0·060%; Sb, 0·52% Ni, 0·050%; Pb, 0·053%; Fe, 0·058%; Bi, 0·003%; S, 0·004%; Se, 0·008%; Te, 0·038%; O, 0·100%. The electrolyte used in refining contains 16% of copper sulphate and 12% of free sulphuric acid; nickel, cobalt, iron, zinc, and arsenic dissolve from the anodes and foul the electrolyte, whilst the other impurities pass into the slime. The electrolyte is purified by crystallisation, or by electrolysis to recover the copper, nickel and free acid. Silver, gold, platinum, palladium, selenium, and tellurium are recovered from the slime. The cathodes are afterwards melted in reverberatory furnaces of 200—250 tons capacity, and the copper oxidised to bring it to the state of 'set copper' containing 4% to 5% of cuprous oxide, in order to get rid of sulphur, and then poled to reduce the cuprous oxide 0·3 to 0·6%. A typical analysis of refined electrolytic copper is given as:—Cu, 99·93%; Ag, 0·001%; Au, 0·00001%; O, 0·045%; S, 0·003%; Fe, 0·0035%; Ni, 0·0015%; As, 0·0015%; Sb, 0·0015%."—F. L. Antisell and S. Skowronski.—*Journal of the Society of Chemical Industry*, Dec. 15, 1916, p. 1221. (J. A. W.)

Heroult Furnaces in the U.S.A. "According to the *Electrical Review* in the past six months the United States Steel Corporation has granted licences for a total of 28 Heroult electric furnaces for steel-making in the United States and Canada, which exceeds by four the number licensed during the full year of 1915. At present a total of 72 Heroult units are either in operation, in course of building, or have been authorised in the United States and Canada. Arrangements for a large number of additional furnaces have been made by various companies through licences from the Steel Corporation during recent weeks."—*Ind. Engineering*, Oct. 28, 1916, p. 283. (J. A. W.)

MINING.

Roller Bearing *v.* Plain Bearings on Mine Cars.—"A test was made at the Greensburg Coal Company's mine at Greensburg, Pa., on the main haulage road underground to determine the saving in tractive effort of mine cars equipped with roller bearings as compared with mine cars equipped with plain bearings under identical conditions of operation. Two types of mine cars were tested, identical in every respect except bearings. One type had roller bearings and the other plain ditto, their location in each case being in the wheel hub. The dimensions of the bearings were 2⅜ in. diameter by 8 in. The gauge of the track was 40 in., the diameter of the wheels 18 in., the wheel base 27 in., and the distance from drawbar to top of rail 15½ in. The roller bearings have a planished outer race with the flexible rollers running directly on the axle. The plain bearings are formed by the hub of the cast-iron wheels. The cars equipped with roller bearings had been in service about two years before this test was made. The plain bearings were run off for some three weeks before the test. All roller bearings were filled with fresh grease before the test. The old grease was not drawn off nor was any cleaning or overhauling done. The lubricant used was a thin grease.

For the actual test two different trains of 20 cars each were used, one made up of cars with roller-bearing wheels, the other of cars with plain bore wheels. All were loaded as uniformly as possible with coal, as in every-day practice. Each car weighs loaded 7,150 lb.; therefore each train of 20 cars weighs 143,000 lb., of 71·5 tons. One train at a time was tested by pulling it by means of an electric locomotive over 4,116 ft. of track. The dynamometer car was inserted between the locomotive and the train in such a way that its own resistance was not indicated on the records. The rails of the track weigh 40 lb. per yard. They were dry and in good condition when these tests were made. The following average values were found :—

Type of Bearings	Average Grade, per cent.	Test No.	Average Draw-bar pull in lbs.	Average speed in miles per hour.
Roller	2·4	4	4,410	5·75
		5	4,350	6·59
		6	4,280	5·56
Plain	2·4	1	5,250	5·70
		2	5,070	5·78
		3	5,190	5·30
Average of tests 4, 5 and 6 ...	—	—	4,347	5·98
Average of tests 1, 2 and 3 ..	—	—	5,170	5·59

To correct these figures for grade, 20 lb. per ton 1% must be subtracted from the above drawbar pull. For the train weight of 71·5 tons and the average grade of 2·4%, the correction amounts to 3,432 lb. for each train. The corrected tractive effort for the roller-bearing cars therefore amounts to :—

4,347 3,432=915 lb. at 5·98 miles per hour and for the plain-bearing cars :

5,170−3,422=1,738 lb. at 5·59 miles per hour.

Expressed in pounds per ton this means for the roller-bearing cars 12·8 lb. per ton, and for the plain-bearing cars 24·3 lb. per ton.

Disregarding the slight difference in speed, the saving in drawbar pull in favour of roller-bearing cars therefore amounts to 47·25%. In other words, a locomotive of a certain size would be able to pull the following number of cars provided the speed is the same in each case :

Grade, per cent.	Per cent. more roller-bearing than plain-bearing cars.
Level	90
1	35
2	22
3	16

Iron and Coal Trades' Review, Aug. 11, 1916, p. 162. (E. M. W.)

Advantages of Turbo Air Compressors. "Turbo-compressors supply an interesting example of the rapidity with which any new type of machine is brought from the initial stages to a practical and serviceable form in modern machine construction. The turbo-compressor, which is to-day constructed in single units of the largest output, has been developed within a period of about ten years. Compressors of this type have been built in sizes ranging up to 60,000 cub. ft. per min. of free air, up to a pressure of 170 lb. per sq. in. gauge when running at a speed of 3,000 revs. per min. This output corresponds to an input of 12,000 h.p. to 13,000 h.p. measured at the shaft.

The outstanding advantages of turbo-compressors as compared with reciprocating compressors may be summarised as follows :—(1) The floor space occupied is much smaller, the capital expenditure is less, and the overall efficiency is higher. (2) Much lighter foundations are required, and the turbine drive permits of the condenser being placed immediately below the turbine with a consequent reduction in the length of the eduction pipe. (3) No internal lubrication of the compressor is necessary, and since with turbine drive forced lubrication is provided to all bearings, a considerable amount of oil is thus saved and less attention is required. (4) The turbo-compressor permits of the use of exhaust steam from winding, hauling, rolling-mill engines, etc. (5) The supply of air from a turbo-compressor is free from oil, which is a *sine qua non* in the case of certain chemical processes. (6) The air delivered by a turbo-compressor is continuous in supply, and not pulsating as in the case of reciprocating machines.

The attainment of high efficiency in a turbo compressor lies in the correct acceleration with least losses, and the careful conversion of energy of motion into energy of pressure. Another vital point is the provision of adequate cooling during the compression process. The multi-stage construction employed in building turbo-compressors permits of the advantages of cooling, and it is possible to approach the isothermal pressure curve more closely than in a piston compressor with staged compression and intermediate cooling."—*Iron and Coal Trades' Review*, Sept. 8, 1916, p. 278. (E. M. W.)

MISCELLANEOUS.

Water-Powers of the World.—"According to Mr. D. B. Rushmore, says the *Electrician*, it is estimated that the water-powers of the world represent about seven hundred million horse-power, this estimate being based on the assumption that the water-powers per square mile is, approximately, 14 h.p. To this total Africa and North America each contribute 150,000,000 h.p., South America 100,000,000 h.p., Asia 225,000,000 h.p., Australia 10,000,000 h.p., and Europe 65,000,000 h.p. Approximate figures place the minimum water-power of the United States at 31,000,000 h.p., and the maximum at 56,000,000 h.p."—D. B. Rushmore.—*Indian Engineering*, Oct. 28, 1916, p. 283. (J. A. W.)

A Novel Method of Handling Boilers to Prevent Corrosion and Scale. — "An account of experiences with a method of preventing corrosion and scale prevention in steam boilers, which differs from the commonly accepted theory of boiler water treatment, in that a high alkalinity is carried in the boiler. It has been commonly considered that a boiler water high in alkalinity has a decided tendency to prime, and this is probably true if no antipriming substance is added. Under the high alkalinity treatment described, boilers have been run with no corrosion for more than a year, and the normal alkalinity has frequently reached 10%, without any tendency to prime.

The treatment was first applied by the author to twelve 64 h.p. water tube boilers at the Fruitvale power house of the Southern Pacific Company, California, which presented one of the most pronounced cases of localised corrosion on record. At the time the treatment was commenced, all other known methods of treatment, including observation for electrolysis, had failed to stop the corrosion, which became so serious that, eighteen months after the boilers were put in service, one-third of the tubes had been replaced.

The treatment consists in adding to the hot-well water a compound known as the Navy Standard Boiler Compound, originally developed by Lieut. Commander Lyon, U.S.N., as the result of numerous investigations. The ingredients of the compound are sodium carbonate, trisodium phosphate, dextrine or starch, and a tannin compound, such as cutch. The sodium carbonate is the main ingredient, and is used to take care of any chemical reactions and render the solution non-corrosive. The tannic acid and starch throw down the scale forming compounds present in ordinary feed water. The trisodium phosphate prevents the rise in surface tension of the solution and consequent priming which would be caused by the original impurities in the water and by the application of the other ingredients in the compound. In using the compound to prevent corrosion, a sufficient quantity must be added to the water of each individual boiler to render the alkaline strength of the solution 3% normal or above.

The use of the compound at Fruitvale resulted in almost cessation of troubles from corrosion.

The results were so satisfactory that the method was extended to locomotives in service in one of the worst locomotive water districts on the Southern Pacific Lines, and to other power plants of the Company's system, all with favourable results. In one particular case, the water carried 230 gr. per gallon of solid matter and nearly every known variety of boiler trouble had been experienced, but the compound eliminated corrosion and precipitated the solids in a soft, slushy form easily washed out.

The Associated Pipe Line is using the compound successfully in twenty-six stations in the San Joaquin Valley, chiefly for the prevention of scale. Most of the stations have three 250 h.p. water tube boilers, and use water containing solid matter varying in amount from 5 gr. to 231 gr. per gallon. In places where the solid content is so very high, it has been necessary to increase the quantity of anti-foaming chemicals above that ordinarily contained in the compound. This has been done, not by changing the composition of the compound, but by adding separately a quantity of the non-foaming ingredient, trisodium phosphate.—A. H. BABCOCK Transactions American Society of Mechanical Engineers.—*Cassier's Engineering Monthly*, Oct., 1916, p. 276. (J. E. T.)

IRON AND STEEL MADE RUST-PROOF.—"Rendering iron and steel rust-proof by changing the surface to basic phosphate salts of iron is the basis of a U.S. patent. Iron placed in a weak solution of phosphoric acid is attacked and an adherent coat of insoluble ferrous phosphate is formed, which an oxidising agent makes basic in character and black. The patentee takes advantage of the fact that the more acid phosphate salts of calcium, magnesium, barium, or other alkali earth metals in solution, react much less violently than when free phosphoric acid is present. By using hydrated manganic oxide and air as oxidising agents in the presence of this acid phosphate, a layer of ferroso-ferric phosphate is formed of suitable thickness and black, rendering the metal rust-proof." *Pages' Engineering Weekly*, Oct. 13, 1916, p. 206. (J. E. T.)

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.—"An announcement of the greatest importance to British industries was made in the Press on December 1st, to the effect that the Government have decided to establish a Department of Scientific and Industrial Research for Great Britain and Ireland, under the Lord President of the Council, with the President of the Board of Education as Vice-President. They have also decided, subject to the consent of Parliament, to place a large sum of money at the disposal of the new Department, to be used as a fund for the conduct of research for the benefit of the national industries on a co-operative basis.

The Board of Inland Revenue have decided, with the approval of the Chancellor of the Exchequer, that no objection shall be offered by their surveyors of taxes to the allowance, as a working expense for income-tax purposes, of contributions by traders to industrial associations which may be formed for the sole purpose of scientific research for the benefit of the various trades, and the allowance would be equally applicable as regards traders' contributions specifically ear-marked to the sole purpose of the Research Section of an adapted existing association. In both cases the allowance would be subject to certain conditions, *e.g.*, the association or the research section to be under Government supervision and the trader's contribution to be an out-and-out payment, made from his trade profits, and giving him no proprietary interest in the property of the association, etc.

In order to enable the Department to hold the new fund and any other money or property for research purposes, a Royal Charter has been granted to the official members of the Committee of the Privy Council for Scientific and Industrial Research, under the title of the 'Imperial Trust for the Encouragement of Scientific and Industrial Research.' The Trust is empowered 'to accept hold, and dispose of money or other personal property in furtherance of the objects for which it has been established, including sums voted by Parliament, to that end.' The Trust can take and hold land, and can 'accept any trusts, whether subject to special conditions or not, in furtherance of the said objects.'

A substantial gift has already been made to the Trust by two members of the Institution of mechanical engineers for the conduct of a research in mechanical engineering to be approved by the Department, in the hope that this example will be followed by other members of the Institution.

Mr. H. Frank Heath, C.B., has been appointed permanent secretary of the new Department, to whom all correspondence should be addressed until December 31st next, at the offices of the Board of Education, Whitehall. On and after January 1st, 1917, all correspondence should be addressed to The Secretary, Department of Scientific and Industrial Research, Great George Street, Westminster, S.W.

On November 30th the Marquis of Crewe received a deputation from the Conjoint Board of Scientific Societies. The deputation, which numbered about 150 representatives of the various branches of science, was introduced by Sir J. J. Thomson, President of the Royal Society, who said that the deputation desired to urge the importance of increased grants for scientific and industrial research. Research in pure science was of vital importance, and had led to a number of discoveries which had proved subsequently to be of the greatest practical value. The discovery of Röntgen rays, for example, arose from a research of a purely scientific character, undertaken with a view to elucidating the nature of electricity.

Research in applied science might lead to reforms, but research in pure science led to revolutions. The State could insure that professors and others engaged on purely scientific research could devote sufficient time to it, and that their income from the professorships was not so small that they had to spend their free time in undertaking work to enable them to live. To neglect pure science would be on a par with omitting to sow seed on land on which a large amount had been spent in manuring and ploughing.

Sir Maurice Fitzmaurice, President of the Institution of Civil Engineers, and Prof. Brereton Baker, of the Imperial College of Science and Technology, also spoke.

The Marquis of Crewe said that we had to provide for the new conditions which would arise in this country, and in the rest of the civilised world, when the war was concluded. The Government had been impressed by the need of coming further to the help of those who were engaged on research work in relation to industry. They had had to consider what could be done to assist the great staple industries of the country in developing systematic research on a large scale. There were cases in which an individual research worker needed a grant to enable him to go on at all, and a sum would be set aside for that purpose. There were some professional societies which stood in need of assistance from time to time to enable them to carry on research work, and this charge would also be met. There was, further an area of research which paid nobody in the pecuniary sense for the time being, and in some of these cases it would be necessary to find the money from public funds. Then there were some researches which were so obviously of purely national importance that no one would be found to finance them if the Government did not do so. Here, again, the Government felt that public money ought to be applied in specific and selected cases.

The matter of scientific research applied to industry was, it was considered, one of the cases in which an exception might be made to the usual plan of procedure by annual estimates. Therefore the Chancellor of the Exchequer was prepared to advise the Government to devote a very large sum, generally estimated to meet the needs for this purpose for the next five years, on a scale which ought to enable them to spend certainly four and possibly five times as much on the co-operation between the Department and the different industries as had been spent for the whole purposes of research by vote hitherto.

They desired to see the creation or adaptation of trade associations on a large scale, which might be able to assess the contribution which the industry was able to make towards systematic research. In some cases it might be found advisable to form a series of distinct associations for research purposes. On the other hand, it was quite possible that an individual great firm having various activities might belong to several associations and make its contribution in respect of the particular class of research which might be proceeded with at a given time. These associations should as far as possible be placed under small committees of direction, including leaders of the particular business, men of science, and representatives of the skilled workers in different trades.

It was proposed to give some further help for technical instruction. The Government had arrived at the conclusion that the present regulations under which technical schools received public money were not quite up to date, and they were going to discuss with the local authorities concerned, and the governors of the schools, certain new draft regulations, which, it was hoped, would both simplify administration and stiffen up the instruction. A substantial addition would be made in the Estimates so as to permit of a levelling up of the grants to a reasonable figure, and also to make improved arrangements for the training of technical teachers, as well as to permit of scholarships being established to carry on selected industrial students to the Universities.

Referring to the work of the Coal Conservation Committee, Lord Crewe said he understood that that Committee and the Advisory Council had agreed upon a series of researches which were designed to establish, on a scientific basis, a systematic economy in the use of fuel. The research was to begin with systematic survey of all the various coal measures in the United Kingdom. It was to examine and experiment on coal under various furnace tests, and the suitability of different kinds of coal to different processes of coking, and so forth.

Although, in the higher forms of discovery, we in this country were not prepared to yield the palm to any country in Europe or out of it, we felt that for many the path of scientific learning had not been made as easy as it ought to be. What was desired was to make the road easy for those sons and daughters of Britain who saw the beacons of science shining ahead of them on a high hill, which it was their life's work to climb."—*Journal of the Society of Chemical Industry*, Dec. 15, 1916, pp. 1200-1201. (J. A. W.)

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Forrest, B. C., *l/o* Florida; Ferreira Deep, Ltd., P.O. Box 1021, Johannesburg.

Macer, L. W., *l/o* Krugersdorp; Survey Office, Brakpan Mines, Ltd., Brakpan.

Price, W. S. V., *l/o* Maraisburg; 2, Amelia Street, Roodepoort.

Thorne, T. L., *l/o* Cleveland; Springs Mines, Ltd., P.O. Box 51, Springs.

Tillard, M. O., *l/o* Johannesburg; New Modderfontein G.M. Co., P.O. Box 25, Benoni.

Turner, A. H., *l/o* Barberton; Apex Section, New Kleinfontein Co., P.O. Box 2, Benoni.

LIBRARY
JUL 22 1920
UNIVERSITY OF TORONTO
149

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. MARCH 1917. No. 9.

Proceedings
AT
Ordinary General Meeting, March 17, 1917.

The Ordinary General Meeting of the Society was held in the South African School of Mines Building on Saturday, March 17th. Prof. J. A. Wilkinson (President) in the chair. There were also present:—

15 Members: Messrs. G. Hildick Smith, H. A. White, J. Chilton, C. Toombs, F. W. Watson, John Watson, Dr. W. A. Caldecott, W. R. Dowling, J. E. Thomas (Members of Council), R. W. Bennett, P. T. Morrisby, E. A. Osterloh, C. Rowe, A. L. Spoor, and T. P. Waites.

8 Associates and Students: Messrs. B. C. Forrest, J. Gibson, E. G. Harding, W. Human, L. H. Hyman, R. W. Irwin, R. Railton, and H. Rusden.

8 Visitors, and Fred Rowland (Secretary).

The President: I regret that unforeseen circumstances have rendered it necessary for us to hold our meeting in a different room, but I think it is better, as we have all gathered together, that the meeting should not be postponed, but should be carried on, even under somewhat adverse circumstances.

The minutes of the meeting held on the 17th February, as recorded in the *Journal*, were confirmed.

ELECTION OF NEW MEMBERS.

Mr. H. A. White and Dr. W. A. Caldecott were appointed scrutineers, and after their scrutiny of the ballot papers, the following gentlemen were declared duly elected to membership.

Grobler, Cornelius Johannes, M.E., B.Sc., P.O. Box 257, Germiston. Mine Overseer.

Mark, Joseph Henry, East Rand Proprietary Mines, Ltd., P.O. Box 57, East Rand.

The following student was admitted by the Council at its last meeting:—

Hyman, Leslie Henry, Government Chemical Laboratory, Hospital Street, Johannesburg.

MINE AMBULANCE COMPETITIONS.

The President: I desire to call attention to the Mine Ambulance Competitions, which will be held for the Surface Workers' Shield on Sunday, 15th April, Underground Workers' Shield on Sunday, 22nd April, and Colliery Workers' Shield on Sunday, 29th April. These competitions, as you know, are held under the auspices of the S.A. Red Cross Society, and it is hoped that the competitions this year will be keener and more enthusiastic than has been the case in recent years.

PROCEDURE AT MEETINGS.

Mr. G. Hildick Smith *(Vice-President)*: With reference to the procedure at our monthly meetings, I think we might well make an interval during the course of the evening, in which there would be an opportunity for members to converse together.

The President: That is, of course, as members wish. Hitherto we have had the interval, unless stress of business prevented it.

SCIENTIFIC AND TECHNICAL COMMITTEE.

The President: You have probably seen in the press recently that the Industrial and Scientific Technical Committee has been formed by the Government, and I think we can congratulate ourselves on the fact that two of our three representatives to the Joint Societies' Committee have been elected to permanent places: viz.: Professor Stanley, on the Industries Advisory Board, and Dr. Caldecott on the Scientific and Technical Committee.

Another of our members, Mr. L. Colquhoun, has also been elected on the Committee, so I think the Society may be proud that it has secured permanent representation on these Committees

Mr. H. A. White *(Vice-President)* I should just like to remark that I think the Government undoubtedly is to be congratulated on its selection. I have ascertained that these positions are entirely unpaid. It has been a practice throughout the civilised world, when Governments require special scientific opinion, that they shall offer no money for it, and I think it is a practice, which would be more honoured in the breach than in the observance.

The President: I do not think we can enter into a controversial discussion of that nature now.

SILICOSIS IN RATS IN A WITWATERSRAND MINE.

By J. Pratt Johnson, M.B., B.S. (Lond.), D.P.H.(Oxon.).

I would like first to express the great pleasure which it affords me to lay before your Society the results of our researches on this subject. These researches were carried out in conjunction with Dr. Watt concurrently with a research extending over $2\frac{1}{2}$ years on the causation, incidence, pathology, symptoms and radiographic appearances of silicosis (miners' phthisis) on the Witwatersrand." This latter research was conducted by Drs. A. H. Watt, L. G. Irvine, W. Steuart, and myself. I propose to illustrate my subject by reference to lantern slides of actual micro-photographs of rat and human lungs. These micro-photographs were beautifully executed by Mr. Holmes, Manager, New Goch G.M. Co., whose skill as an amateur photographer is sufficiently well demonstrated in the excellence of these productions.

Previous publications on the subject of rat silicosis have given rise to doubt as to the development of silicosis in rats which inhabit the underground workings of the mines of the Rand, and it was suggested that rats are immune from this disease owing to certain peculiar anatomical characters, and to the fact that they breathe only through the nose.

This doubt has now been removed as the result of a research carried out privately, which was primarily undertaken to obtain additional knowledge on certain obscure points in the pathology of miners' phthisis as it occurs on the Witwatersrand, and to provide additional evidence in regard to the mode of origin of various pathological lesions arising during the course of the disease in man. At the suggestion of Dr. A. H. Watt, of the Simmer and Jack G.M. Company, the white rat was chosen as being a hardy animal of convenient size, whose normal habitat simulated the underground conditions, and whose high relative degree of resistance to human tuberculosis offered a good chance of studying silicosis uncomplicated by the presence of tuberculosis.

It would appear that of other animals white mice are especially suitable, as these tiny creatures are the most resistant of all animals to tuberculosis.

As the expectation of life of the local white rat was not known, it was realised that the animal might succumb from natural causes, before a sufficient time had elapsed to allow of the development of any pathological lesions which could be identified as silicosis. It was, therefore, decided to place the animals under the worst possible conditions in a mine, in order to ensure that some definite results might be obtained as early as possible. Arrangements were accordingly made in December, 1913, with the Manager of the Simmer Deep to place a number of white rats separately in cages, in the underground workings. The cages were fixed in one of the worst places in the mine, at the top of a stope, so that the animals were exposed to the dust and fumes conveyed by ventilation currents after blasting. A number of these animals have been kept underground continuously up to February, 1917, and have been carefully fed and looked after, owing to the kindness of Mr. MacGregor, Manager of the Simmer Deep G.M. Co. At intervals of 7 months, 19 months, $2\frac{1}{2}$ years, and 4 years, the rats have been removed, killed, and examined. The animals appeared to be in a healthy condition underground, and examination of those rats which were killed showed them to be fat and well nourished. They were killed by severing the vessels of the neck. Control examinations were made with a number of brown rats, which were caught in the town, and a small number of white rats.

Although apparently healthy and in good condition, all the rats removed from the cages underground which were examined showed pathological changes which were found to be progressive in character, bearing a close analogy to similar phenomena in uncomplicated human silicosis.

Before proceeding to a description of silicosis as it occurs in the white rat, it is convenient to consider for a moment the lymphatic system of the rat's lung, and also to note one or two points in regard to the histology of a rat's lung. On examination of sections of a normal rat's lung it will be noticed that the alveoli are relatively much larger than the alveoli of a human lung.

It would appear that the lymphatic system of the rat's lung bears a close analogy to that of a human lung. The lymph from the alveoli is collected into a network of lymphatics, whence the lymph is conveyed by means of small lymphatic vessels, which run in association with the bronchioles and vessels. A well-defined system of sub-pleural lymphatics also appears to be present. Scattered along the larger vessels and bronchioles, and also in the sub-pleural region, are small accumulations of lymphoid elements; these accumulations are specially marked at points of bifurcation of the bronchi. The lymph from the larger vessels is conducted to the root of the lung, and thence to a number of glands, which lie close to the bifurcation of the trachea. These glands are small ovoid structures of a pale fleshy colour, which vary somewhat but are commonly about the size of a millet seed.

It would appear that rat silicosis, which is definitely progressive in character, can be sub-divided into similar stages to those adopted in the pathology of human silicosis, but in view of the somewhat limited experience we have had of the former disease, it is not deemed advisable at this juncture to do more than describe the conditions found on examination of the rats after intervals of exposure of seven months, nineteen months, and two and a half years.

(a) *Examination of Two Rats Sent Alive by Dr. A. H. Watt, in June, 1914, after an Exposure of Seven Months.*

On opening the thorax no adhesions were found, and no thickening of the pleura.

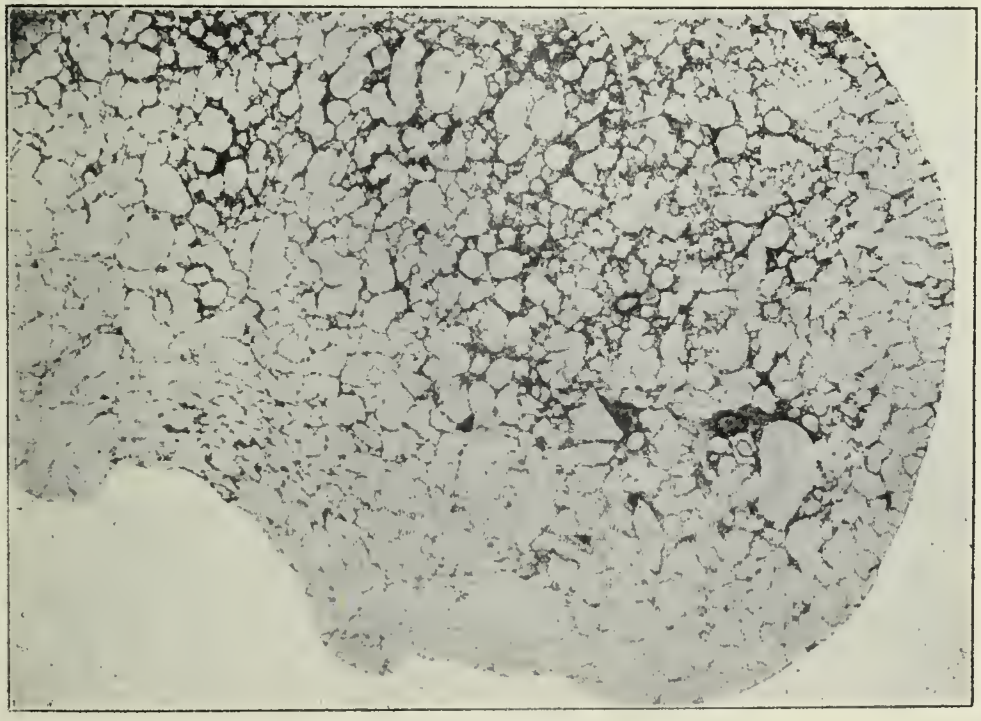


Fig. 1.—Section of normal rat's lung showing bronchial tubes, infundibula, vessels, and lymphatics. The alveoli are relatively larger than in the human lung (Magnification ×25).

Both lungs were coarsely stippled with fine black pigment, which was most marked at the anterior edges. No nodules could be felt. The lungs were well aerated, and, except for a certain amount of congestion, appeared to be normal.

Examination of sections of these lungs showed a catarrhal condition, together with a good deal of congestion, with shedding of alveolar epithelium. Numerous "dust cells" were found in the alveoli, in the interalveolar walls, and in the loose connective tissue surrounding the blood vessels and bronchioles. They were more closely aggregated around the lymphoid nodules described above, occurring on the course of the vessels and bronchioles, and also in the subpleural region. In portions of the lung where the dust cells appeared to be most numerous the alveolar epithelium and interalveolar tissue showed marked proliferation, consequently much reducing the size of the alveoli affected. No microscopic nodules were found.

The lymphatic glands were slightly enlarged, and of a faint greyish colour. On section these glands showed accumulation of dust cells in the lymphatic sinuses, but the lymphoid elements did not appear to be decreased.

In places the alveolar walls were thickened by overgrowth of connective tissue.

The net result of the change was to produce diminution of the total air capacity of the lung.

(b) *Examination of Three White Rats Sent in Alive by Dr. A. H. Watt on July 15th, 1915, after an Exposure of Nineteen Months.*

The observed appearances of these rats were practically similar. On opening the thorax no adhesions were found; the lungs were congested, and the pleura was closely stippled with a varying number of small rounded whitish areas, about the size of a small pin's head, which slightly protruded above the surface of the pleura, producing a finely granular or mammillated appearance. One rat showed this condition to a marked degree and subsequent sections of this lung showed it to be in a more advanced condition of silicosis than either of the other two rats. The lymphatic glands were found to be enlarged, of a dark slate grey colour, hardened, and about the size of a somewhat flattened pea. On section, all these lungs showed a marked degree of generalized nodular fibrosis. The pleura was thickened and the sub-pleural ovoid structures above described were seen to consist of single fibro-cellular nodules, composed of closely packed connective tissue cells, together with a number of small lymphoid cells, with deeply staining nuclei. Similar nodules were found scattered throughout the lung.

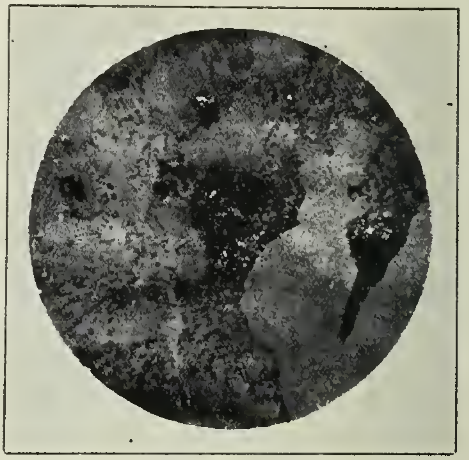


Fig. 2.—Section of rat's lung after an exposure of 19 months underground, under polarised light, showing aggregation of refractile particles most marked in silicotic nodules. Under higher magnification a considerably greater number of these particles than is shown above, is seen (Magnification ×120).

In places these nodules lie close together, and are seen to form larger areas by their partial coalescence. The nodules appear to originate in the following situations:

1. In the sub-pleural lymphatics.
2. In the alveolar walls.
3. In association with the lymphoid nodules along the course of the vessels and bronchioles.
4. In the alveoli by the proliferation of the epithelium, which is subsequently replaced by young connective tissue cells.

The walls of the bronchioles and arteries are markedly thickened, and in some cases arteries in process of obliteration are observed. The alveolar walls are thickened and the alveoli are seen to contain numerous epithelial cells, many of which contain siliceous particles; the alveolar capillaries are markedly congested. On examination of these sections with polarised light the nodules are found to be densely packed with siliceous particles, which are also found in the alveolar walls, under the pleura, along the course of the vessels and bronchioles, and in the lymphatic glands. The siliceous

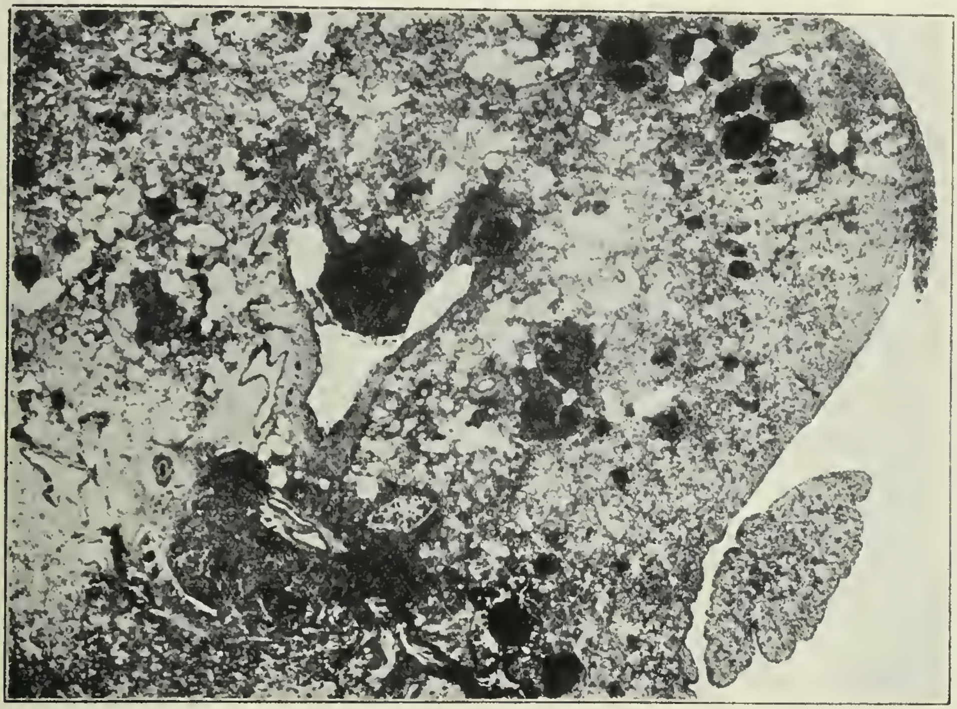


Fig. 3.—Rat Silicosis. Condition found after nineteen month's life underground. Numerous fibro-cellular nodules are present—one is especially noticeable at the bifurcation of a bronchial tube. The alveolar walls are thickened and the alveoli are either reduced in size or obliterated (Magnification ×25.)

particles found in the nodular areas above described are in many cases actually within the connective tissue cells of which the nodule is composed. Other particles, however, appear to lie between the cells of the fibro-cellular growth. Sections of the lymphatic glands showed the lymphatic sinuses to be entirely replaced by an overgrowth of young fibrous tissue cells, many of which are found to contain siliceous particles. It is noticeable that these siliceous particles are not found in those areas occupied by the lymphoid cells. The overgrowth of young fibrous tissue cells appears to produce at least a relative reduction in the number of lymphoid cells present, and at the same time is responsible for the increase in the size of the gland.

(c) *Examination of Two Rats Sent in by Dr. A. H. Watt on May 9th, 1916, after an Exposure of Two and a Half Years.*

These animals on examination were found to be fat and in good condition. On opening the thorax no adhesions were found; the lungs were markedly congested, and the

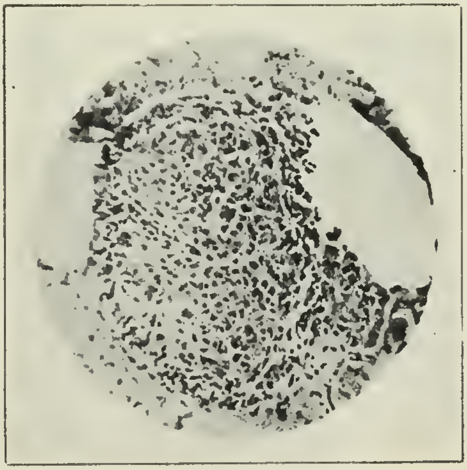


Fig. 4.—Silicotic nodule from rat's lung after 2½ years' life underground. The nodule is composed of dense fibro-cellular tissue with a peripheral zone of round cells. No signs of "breaking down" were seen in any of the nodules (Magnification ×300).

pleura was studded with a large number of whitish areas, producing a finely mammillated appearance, as described above. Sections showed the alveolar capillaries to be markedly congested, and many of the alveoli were entirely obliterated by the proliferation of the epithelium. A large number of fibrocellular nodules were found scattered throughout the lung, many of which were found to have coalesced, producing a fairly considerable area of fibro-cellular consolidation. The walls of the vessels and bronchioles were markedly thickened, as were also the alveolar walls. The result of all these changes was a marked diminution in the total amount of functional alveoli, the shape and size of the alveoli having been markedly modified. It would appear that the fibro-cellular tissue, of which the nodules described are composed, is subsequently replaced by dense fibrous tissue commonly found in advanced human silicosis. That this will be found in the lungs of rats, which have been underground for longer periods is forecasted by the condition found on examination of the lymphatic glands of the above rats, which showed dense fibrosis in a marked degree. The glands are of a dark grey colour, hard, and enlarged to the size of a small haricot bean. On examination, the lymphoid cells were found to be markedly reduced, the greater portion of the gland being taken up by a large fibrotic nodule, which in the centre consisted almost entirely of fibrous tissue, in which a few stellate cells were found. The microscopic examination of all the sections for bacillus tuberculosis and other organisms was made, with a negative result.

General Remarks.

The foregoing research on Rat Silicosis proved of considerable value and help to a research on "Human Silicosis" as it occurs on the Witwatersrand, which was carried on, at the same time, by the writer in conjunction with Drs. Andrew Watt, L. G. Irvine, and W. Steuart.

The development of silicosis in a rat very closely resembles the development of silicosis in a white miner, who exhibits a high degree of resistance to pulmonary tuberculosis. It should be remembered, however, that these animals were kept underground during the whole of the time of the experiment, and were exposed not only to the injurious influences of siliceous particles in the air, but also to the fumes of explosives immediately after blasting. It is necessary to remember this fact, when considering the time element in the development of silicosis. Undoubtedly if these animals had only been subjected to the influence of mine dust during the ordinary periods of work and had been allowed fresh air and exercise in the intervals, the progress of the disease would have been very much slower.

It is regretted that it has been found impossible to include in this paper the results of the examinations of the rats removed after four years' continuous exposure underground. Further experiments will be carried out with these rats to test any alteration in their susceptibility to human tuberculosis, resulting from the silicotic condition of their lungs. It is proposed to inoculate these animals with the human bacillus tuberculosis, and to use as controls healthy white rats, which have not been exposed to underground life. Theoretically it would be expected that the affected rats will be more easily infected with the human B. tuberculosis than the normal healthy rats.

The more extended use of dust-laying appliances has resulted in a considerable reduction, and in some cases practical disappearance, of the naked-eye visible dust in the underground air of the mines. While this constitutes a considerable advance, this fact is liable to give rise to a sense of false security. It is well known that the most dangerous particles of silica are the very finest particles, which are invisible to the naked eye and visible only with the aid of the high powers of the microscope. Although dust-sampling affords valuable information, the statistics obtained thereby cannot be accepted as a reliable index of the working conditions except in regard to the actual time and place of sampling; and taking for granted that every care has been taken to avoid technical errors in the handling of the apparatus. It is possible that the occurrence of silicosis in rats which have been exposed to underground conditions may afford a valuable means of recording the actual silicosis-producing conditions obtaining in any mine, over a given period. An obvious criticism of this method is that what may prove unhealthy for the rat may not prove unhealthy for man. This criticism, however, can be waived aside, for it has been proved that both rat and man develop silicosis when they are exposed to the dust produced by mining operations on the Witwatersrand. It should further be remembered that the disease is produced as the result of mechanical irritation, which can reasonably be expected to produce a similar change when embedded in any animal tissue.

The first sign of silicosis was noticed in animals after a continuous exposure of seven months underground. It is important that the periods of exposure of the animals should conform with those of the workmen. The examination of these rats would reflect actual working conditions over a given period, which should be not less than 9 to 12 months. The adoption of this method would enable comparisons to be made between mine and mine, between portions of the same mine, and between different systems of ventilation, etc. The results in time would afford valuable evidence as to what progress is being made in each mine in stamping out the disease. If conditions are improving the animals will remain for an increasing period free of silicosis.

The President: In listening to this paper a good many memories returned, of which the first was the memory of the first paper that was read before this Society on miners' phthisis, and the violent discussions which it caused. Those discussions were practically devoid of the experimental information; such as we have had to-night, a somewhat unfortunate circumstance. In some brief remarks which I made at that time, I referred to the absence of experimental data, for which I was called to account because I had dared to say that our experimental knowledge at that time was by no means sufficient for the foundation of definite conclusions. Since that time we have advanced very considerably. A large amount of really good experimental knowledge has been brought forward, and to-night we have entered, I think, another phase of this question, namely, whether animals can be used as an index of the various stages of silicosis which can occur in man.

I cannot now attempt to discuss the paper, but there are one or two expressions used in the paper to which I should like to refer. "It would appear," says the author, "that the lymphatic system of the rat's lung bears a close analogy to that of the human being." If guarded language like that is used, care must be taken in drawing dogmatic conclusions from the results of the experiments made upon rats. The expression "it would appear" occurs once or twice, showing that he is not very certain.

There is one question I should like to ask, namely, has the lymph been analysed for the amount of dust which it might contain? Also, does the dust only settle in the lungs? If it settles anywhere else along the lymphatics it probably means there are other tissues of the body which are diseased, as well as the lungs; the latter probably most of all because the dust reaches there first; but, if any other tissues are diseased, it means additional complications are set up, besides those which are set up in the alveoli of the lung.

I think the Society is to be congratulated upon this paper, and I think the author is to be congratulated upon the large amount of experimental work which a paper like this entails. In your name I beg to propose a most hearty vote of thanks, and at the same time to tender our thanks to the gentleman who prepared the beautiful slides which we have seen this evening.

Mr. G. Hildick Smith (*Vice-President*): In contributing to the discussion on a paper entitled "The Mine Dust Problem," read before this Society in January, 1911, by Dr. Aymard, *inter alia*, I then made the following remarks:—

> "As to the medical aspect put forward by the author, we are here again guessing at present. The writer would like to suggest that an experiment should be conducted with mine rats. It will be necessary for us to determine whether the lungs of rats living in the mines are affected with silicosis, if so, then healthy rats or other animals should be obtained, kept underground, some continually, others during the various shifts only. Some in cages or what not, so that they cannot inhale dust and others alongside them so that they can inhale dust, and after various periods post mortem examinations should be carried out on their lungs, etc. Much could possibly be learnt in this way."

Dr. Pratt Johnson's paper has answered the question as to whether rats do contract silicosis. It has been fortunate, from the point of view of research, that rats when placed underground in such a position that they are subjected to dust and fumes produced by blasting operations, begin to show signs of silicosis in as short a period as seven months. The author mentions that the next stage in the research work on this subject, which he and his colleagues are undertaking, is to investigate the effect of tuberculosis combined with silicosis in rats. A more important work, I think, would be to prove how we can prevent rats from contracting silicosis underground. If this can be done, assuming that human beings and rats are about equally susceptible to silicosis, then we shall have obtained very valuable information, which could be used in helping to prevent silicosis in the underground employees in the mines. At the present time, with this object in view, I have rats underground at the Bantjes Consolidated Mines, in duplicate cages made of zinc sheeting, these cages, with their occupants, are placed near the fan on its upcast side. The rats in one side of a duplicate cage are subjected to all the fumes and dust from blasting, but on the other side of the cage the rats are living under flannel screens through which all the air they breathe has to pass. Up to the present the rats have been living under these conditions for about six months. I hope at some later date Dr. Pratt Johnson will find that the rats under the screens have less silicosis than those in the open cages. Although there is still room for much research work on this important subject, Drs. Pratt Johnson, Watt, Irvine, and Steuart are to be congratulated on the valuable piece of private research work they have carried out.

I have great pleasure in seconding our President's vote of thanks to Dr. Pratt Johnson for his most interesting and instructive paper.

The President: May I call upon Dr. Watt, one of our visitors, to make a few remarks on the paper?

Dr. A. H. Watt (*Visitor):* When I put these rats down the Simmer Deep I wanted to give them silicosis in as short a time as possible. The rats were down 24 hours out of the day and they were down at blasting time and after blasting time, when no miners were in the mine at all. We have also other rats, that were kept at the station. They have not been examined. The extraordinary thing about the rats is how healthy they were. I had to separate the males from the females; they were breeding so fast. Some of the rats examined were born underground. The experiments are still going on. I am glad of Mr. Hildick Smith's valuable suggestions as to protecting them from dust.

There is one thing, which I think must strike us all, even from casual observation, and that is, that the means taken to allay the dust are effective. We are not seeing nearly so much silicosis as we did some time ago. That is shown by the figures of the Miners' Phthisis Board and also by the examination of patients in general practice. At one time we thought the minimum time a man could take to develop silicosis was two years. I am quite satisfied myself that it now takes very much longer. The dust sampling of the mines shows an improvement. I think the present method of dust sampling does not show the true state of the mines. Far too few samples are taken Eight samples may be taken. If one happens to be bad, it vitiates the whole. If one or two happen to be extraordinarily good, the same thing happens. Perhaps it is not possible to take more dust samples.

I think Dr. Pratt Johnson's suggestion of keeping animals underground will prove a very good index as to the freedom from dust of the mines.

I have not very much to add to what Dr. Pratt Johnson has said. One thing I thought might be rather confusing. He spoke about pigmentation of the lungs. That is not due to silica. It is due to the carbon pigment which is inhaled at the same time, and the amount of carbon pigment in the lungs forms a good idea of the amount of silicosis.

Dr. F. S. Lister (*Visitor):* I have not many remarks to make. I have done very little work in connection with silicosis. Most of what I know about it has been gathered from the work of others, such as Dr. Pratt Johnson, Dr. Pitchford, and other workers. I do not quite agree that the use of the white rat underground will show us much as to the quality of the mine air as the miner himself breathes it. It would seem to me, especially regarding the conditions in the mines in these days, that in order to judge the state of the mine air, the rats must be taken down at the commencement of every shift and brought up at the end of every shift. If the rats are left there during the whole time the blasting is going on, no one can claim that the miner is subject to that atmosphere. Under the present conditions of the mines, as I am given to understand, I should imagine a rat, if taken down every shift and brought up at the conclusion of every shift, would probably not develop much silicosis in five years, and that would seem rather a long time to wait for such tests. I still think dust sampling will be the solution of the question. Of course, in such case it behoves those responsible to do their utmost to concentrate their efforts on dust sampling. The methods at present, good as they are,

are probably still poor in comparison with what they might be. Research should be done, so that we can have a definite indication as to what are the number of samples necessary to give an accurate estimate of the "dust" conditions. On the whole I consider dust sampling is a better index than the use of white rats, which I think would take too long under the necessary experimental conditions to develop an easily demonstrable silicotic condition of the lung.

Mr. G. Hildick Smith *(Vice-President)*: In regard to the number of dust samples taken underground, since July, 1916, most of the mines have had their own dust samplers, before that time dust samples were taken by the Chamber of Mines Dust Sampling Department. At the Bantjes Consolidated Mines we have taken about 710 samples since July. The actual results of the sampling may be somewhat incorrect, due to possible errors in the method of sampling. In July the average of the samples taken by our own sampler during the month was 6·4 mgm. per cub. metre, whilst last month the average was 2·3 mgm. per cub. metre.

The President: I should like to ask if Dr. Pratt Johnson cares to reply now or would prefer to leave his reply to a later meeting.

Dr. Pratt Johnson: I think it would be convenient that I should reply now.

In regard to the rat's lymphatic system, I use the expression "it would appear," and I do so advisedly, because the amount of work done on this particular point does not justify my being dogmatic about it. This research has been carried out in the rush of ordinary private work under considerable difficulties. At the same time I believe that the lymphatic system of the rat's lung is not materially different from the lymphatic system of the lungs of larger animals. It has to effect the same purpose; it occurs in the same tissues. Furthermore, the lymphatic system may best be studied under conditions giving rise to the presence of foreign bodies in the lymphatic stream enabling the course of any foreign particle to be traced from one position to another, owing to the fact that it shows up easily in sections.

Owing to the large amount of pigment, together with silicious particles present in mine air, one is able to trace the course of the lymphatics. The lymphatic channels are densely packed with these pigmented cells, and the accumulations of lymphoid tissue become the centres of deposit of pigmented dust cells.

In regard to the analysing of lymph, I think it would be rather a difficult thing to collect lymph from the rat's lung. I have not done it. In regard to the presence of dust in other organs of the body, examinations were made with a negative result. Similarly in human silicosis, it is not common to find dust in other organs. The main attack is on the lung itself. Any effect that the dust may have on other organs of the body may be considered to be negligible.

I should like to make it quite clear, however, in reply to the President's remarks, that the detailed histology of the lymphatic system of the rat's lung is a point which is only ancillary to the main object of this research. The work completed on this subject has definitely demonstrated, to my satisfaction, that rats do develop silicosis when exposed continuously to underground conditions on the Witwatersrand for a sufficiently long time. On this point I take my stand.

It is very interesting to hear from Mr. Hildick Smith in regard to his previous suggestions as far back as 1911, and that he is at present conducting experiments in regard to the prevention of silicosis in rats.

With regard to Dr. Watt's statement about pigmentation of the lung, possibly I may have been misunderstood. I entirely concur with his statements. Dr. Lister points out the difficulties of conducting experiments with rats. No doubt there are difficulties, but where there is a will there is a way. My suggestion is that white rats be used to supplement adequate dust sampling.

In regard to dust sampling, Mr. Hildick Smith states that a larger number of samples are now being taken. It is really a matter for those concerned, who are handling dust sampling experiments, to say how many particular samples are required in order to eliminate the experimental error as far as possible.

I should like again to thank you for the opportunity of bringing this research before your Society.

THE VALUATION OF MINES.

By Prof. R. A. Lehfeldt, D.Sc..

(Printed in Journal, September, 1916.)

REPLY TO DISCUSSION.

Dr. R. A. Lehfeldt: Mr. White has made a useful and perfectly sound addition to my paper. His formula $T = \sqrt{\frac{cX}{Q}}$ is one that should be commended to the notice of engineers.

The positive sign before $\frac{cX}{T^2}$ in the equation of page 2 is, as Mr. White points out, a misprint.

In reply to Mr. Weston: By accrued capital I mean the capital accumulated at interest from the date at which each instalment is spent up to the given date, and I imagine that Mr. Kotzé uses the expression in the same sense. The figures of accrued capital for certain mines in my paper are copied from Mr. Kotzé's memorandum.

NEW APPLICATIONS OF THYMOLPHTHALEIN AND NAPHTHOLPHTHALEIN, INCLUDING RAPID METHODS FOR ANALYSING LIMESTONE AND AMMONIUM SALTS.

By James Moir, M.A., D.Sc., F.I.C. *(Past-President).*

(Printed in Journal, February, 1917.)

DISCUSSION.

Mr. John Watson, F.I.C., *(Member of Council):* My object in making these few remarks is to draw attention to what I consider the mispronunciation of the name of a fairly well-known organic compound by the author, the President and others, who spoke of the indicator as "thimol-taleen," and my contention is that the name should be pronounced "timol-thaleen."

In proof of this, thymol is a derivative from the oil of thyme, a herb which, either in the wild or garden state, has been familiar to the English, at least since Shakespeare wrote:—"A Midsummer-Night's Dream," and his contemporary, Francis Bacon, wrote his essay, "Of Gardens." Phthalein is derived from phthalic acid, obtained by the oxidation of naphthalene, which is present in coal-tar in proportions varying from 5% to 10%.

As one who has an inborn reverence for our English language, I plead that we should have these names pronounced, so that he who hears may trace. In these days, when ancient British parks are being ploughed up to grow wheat and potatoes, a crop of thyme might not be amiss in a South African garden, and thyme seed can be purchased cheaply from the local agent of a good British firm.

South African-made oil of eucalyptus was exhibited here a few years ago. This is a start, but more South African products, both inorganic and organic, are required.

The President: As the point of pronunciation has been raised, I might remark that I noticed, when Mr. Watson was reading his contribution, that he lapsed into using that which he condemns in others!

Whilst on the subject, I should like to point out to one of our members that phenolphthalein and phenolphthaline are two quite different substances.

The meeting then closed.

New Book.

The President's Address and the Sectional Addresses. British Association for the Advancement of Science, Newcastle-on-Tyne Meeting, 1916. Published at the Offices of the Association, Burlington House, London, W. Price 2s.

This year the Presidential Addresses appear bound in a convenient volume. The President (Sir Arthur Evans) discoursed on "New Archaeological Lights on the Origins of Civilization in Europe." In the *Chemical* section, Prof. G. G. Henderson, D.Sc., F.R.S., traced the progress of pure and applied chemistry during the twenty-seven years which had elapsed since the previous meeting on Tyneside. The latter portion of his address dealt also with the question of government aid to research work.

In the *Geological* section, Prof. W. S. Boulton, D.Sc., dealt with the work of the geological survey, the development of concealed coalfields, the geology of petroleum and underground water.

President Gerald Stoney, F.R.S., in the *Engineering* section dealt with the British slowness to appreciate scientific education, and had a good deal to say on modern labour questions.

In the *Agricultural* section, Dr. E. J. Russell's address covers twenty pages, reviewing recent work on soils, fertilisers and crops.

J.W.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Estimating Metallic Aluminium in Aluminium Dust.—"*Gasometric Method with Sodium Hydrate.*—Since metallic iron dissolves in hydrochloric acid with evolution of hydrogen, it was thought that this source of error could be eliminated by utilizing the reaction,

$$Al + NaOH + H_2O = NaAlO_2 + 3H$$

The theoretical amount of hydrogen obtainable by dissolving a given weight of Al is the same as with HCl, but metallic iron is insoluble in caustic soda. Using 50 cc. of a 2% solution of NaOH for 200 mg. of the dust, the reaction starts almost instantaneously in the cold, and proceeds for some time without artificial heat. A precipitate, apparently consisting of ferric hydroxide, hydrated silica and perhaps alumina, remains in the generating flask when the latter fills with water and entangles the residual gas in small bubbles, but this can generally be remedied after transfer to the receiver, by corking the latter and agitating briskly.

Contrary to the supposition, the results with NaOH were generally slightly higher than with HCl, as will be seen in Table 3.*

Table 3.—Results of Gasometric Tests

Sample No.	Description.	Metallic Aluminium (Mean Result) By HCl Al	By NaOH Al
1	Pure aluminium granules ..	99·6	99·6
2	Standard bronze powder ...	90·4	90·3
3	High-grade aluminium dust	91·6	92·6
4	Low-grade aluminium dust .	76·4	77·2
5	Medium aluminium dust ..	88·5	90·7

Samples 3, 4 and 5 represent products obtained in Charles Butters & Co.'s Oakland plant.

The volumetric method with ferric sulphate and permanganate described in the previous article remains the only one rapid and simple enough for routine testing. It has been simplified and improved by adopting a standard solution of acid ferric sulphate, consisting of 100 gm. pure ferric-sulphate to which distilled water is added and then 250 cc. of concentrated sulphuric acid. This mixture is heated to boiling until the ferric sulphate has completely dissolved, then cooled and finally made up to a litre with distilled water. For each test on 100 mg. of dust, 50 cc. of this standard solution is used. More uniform results are obtained than when the dry salt is added before acidulating.

I may add that attempts to check the accuracy of the other processes by gravimetric methods were not altogether satisfactory. In the phosphate method a portion always passed through the filter and further boiling of the filtrate was required for its recovery: nevertheless, the final results were generally too high, and the method proved tedious and troublesome.

In the oxide method the final precipitate could not be accurately weighed except in a closed vessel, as it increases in weight rapidly on the balance: it seems to be hygroscopic, perhaps owing to persistent retention of traces of sodium chloride."—J. E. Clennell, *Engineering and Mining Journal*, Aug. 12, 1916, p. 309. (H. A. W.)

Utilization of Nitre Cake.—"Caustic soda and purified sodium sulphate are obtained from nitre cake by the following series of reactions:—I.

$$(3Na_2SO_4 + H_2SO_4 + 2CaSO_3 = 2NaHSO_3 + 2CaSO_4 + 2Na_2SO_4.$$

The calcium sulphate is removed, and lime is added with agitation:

$$\text{II. } 2NaHSO_3 + 2Na_2SO_4 + Ca(OH)_2 = Na_2SO_3 + CaSO_3 + 2Na_2SO_4 + 2H_2O.$$

The calcium sulphite is removed and more lime added:—

$$\text{III. } Na_2SO_3 + CaSO_4 + 2Na_2SO_4 + 2H_2O + Ca(OH)_2 = 2NaOH + 2CaSO_3 + 2Na_2SO_4 + 2H_2O.$$

During reactions II. and III. (which may be combined in one operation), heat may be applied and also an augmented pressure. The calcium sulphite is removed, washed, and used over again: the caustic liquor is evaporated until the sodium sulphate crystallises out, and after its separation, the liquid is further evaporated, if necessary, to dryness. The apparatus for I. is a leaden vat provided with a cover and stirrer: that for II. and III. is similar, but means for applying heat is added."—J. Grossmann.—*Journal of the Society of Chemical Industry*, Oct. 31, 1916, p. 1059. (J. A. W.)

Rapid Assay of Lead.—"The following method for the approximate quantitative determination of lead may be of value to metallurgists, mining engineers, prospectors, and others who have occasion to estimate quickly and with reasonable accuracy the lead content of certain lead compounds and minerals. The method is based on the reduction of lead compounds by nascent hydrogen.

An aluminium plate 2 in. wide, 5 in. long, and 0·03 in. thick is used. About ¼ in. from each end of the plate concave cups are formed by placing the plate over one of the thumb-holes of a crucible-tongs, or over a suitable ring, and striking it with a pestle. The diameter of the cup need not be more than 1 in. and the depth 3/16 in. Before using, the aluminium plate is rubbed with emery-paper or sand so as to clean the surface from the aluminium oxide coating that hinders the action of acids. Each cup will serve for fifteen determinations.

From 0·15 gm. to 0·2 gm. of the finely powdered sample is placed in the cup on the aluminium plate (it may be weighed directly on the plate in the cup), and moistened with a drop or two of dilute (1 : 3) hydrochloric acid. More acid is added, drop by drop, until its action on the aluminium is well started. The sample is subjected to this treatment for several seconds, or until the original colour of the sample almost disappears or is changed markedly. By this time the sample becomes spongy, may be turned over by a pointed glass rod or gently stirred, and more acid is added drop by drop, if necessary. After a minute or two the contents of the cup are stirred with a pointed glass rod for five minutes, or until all indications point to the completion of the reaction. In the case of the lead sulphide, the fact that sulphuretted hydrogen is no longer evolved is a good indication for the end of reaction. With coloured lead compounds the disappearance of the colour is indicative that the reduction is over. In my experiments the reductions took five to ten minutes.

When the reduction is complete, a little pure water is added to the cup, and after gentle stirring

---

[*Probably owing to silicon counting as aluminium. Ed. Com.]

the liquor from the cup is decanted; this operation is repeated four or five times, or until the wash water shows no acid reaction (litmus test or 'tongue touch'). Now the spongy metallic lead in the cup is pressed together with a glass rod so as to make it solid and compact, then a filter-paper is pressed over the lead to dry it as completely as possible. Finally, one drop of water is placed near the cup on the plate, which is now warmed above a small flame or a lighted match, or any convenient small source of heat, until the water is evaporated; this also dries the lead metal in the cup. The dried lead is now detached from the plate by a pocket knife and weighed, and the percentage of lead is calculated on the original sample.

This method is simple and quick, and sufficiently accurate to be of value in many instances of rapid estimation of lead in minerals and compounds."—G. Torossian.—*Queensland Government Mining Journal*, July 15, 1916, p. 335. (H. A. W.)

METALLURGY.

Solvent Power of Cyanide Solutions. "It has been stated that zinc-potassic cyanide is a fairly good solvent for gold, and that in the presence of alkali it forms an alkaline zincate with regeneration of free KCy.

Possibly here again the dilution (and consequent dissociation) may be an important factor, but the two following tests do not confirm the former statement—although the results would probably have been different if ore had been acted on instead of a strip of gold.

The tests are solvent activity tests made under the same conditions as those described in this paper, except that in No. 1 the agitation was only continued for a few hours while No. 2 had the usual 16 hours hours' agitation. The same zinc sodium cyanide solution was used, and lime, when added, was in the form of clear lime water. Check tests were made with NaCy, with and without lime.

These results are sufficiently remarkable, especially as regards the action of lime on NaCy.

Total KCy Per Cent.	CaO Per Cent.	Gold Dissolved m.g.	Maximum Amount of Gold possible to be dissolved m.g.	Per Cent. of KCy present used in Dissolving Gold.
0·026	*Nil*	69·2	78·8	87·8
0·030	0·020	83·8	90·9	92·2
0·042	0·041	31·5	127·3	24·6
0.136	Trace	243·3	412·2	58·9
0·136	0·074	3·5	412·2	0·1

	No. 1 Test Short Agitation.			No. 2 16 Hours Agitation.		
	Total KCy Per Cent.	CaO Per Cent.	Gold dissolved m.g.	Total KCy Per Cent.	CaO Per Cent.	Gold dissolved m.g.
Na_2ZnCy_4	0·149	*Nil*	9·5	0.149	*Nil.*	12·5
Na_2ZnCy_4 + CaO ...	0·149	0·079	1·3	0·149	0·074	1·45
NaCy	0·139	Trace	142·8	0·136	Trace	243·0
NaCy + CaO ..	0·139	0·070	Trace	0·136	0·074	0·5

Neglecting test No. 1, which had less than the usual agitation, it is interesting to compare No. 2 with similar tests also made on pure solutions, but of lower strength, both in lime and cyanide, and shown in Tables 3 and 4.

It would seem that if the dilution be sufficient, a little lime does no harm, but its retarding effect increases with concentration. It is also certain that this retarding effect of lime is nothing like as great when dissolving gold ore, but the reason for this difference seems obscure.

Thiosulphates seem to be quite innocuous or even beneficial as regards extraction—their solutions are fairly stable in air, not readily absorbing oxygen—the bad effects come rather from their reduction. If zinc dust be added to a solution containing thiosulphate it is reduced to sulphide and forms ZnS. This reduction can easily be seen by adding zinc dust, together with a little PbO or $PbCO_3$ to such a solution—which is soon darkened by formation of PbS. Also soluble sulphide is formed if a similar solution is treated in a shallow dish, with mercury, in which a little sodium is dissolved. Precipitation is greatly interfered with by this reduction—a remedy being the addition of lead acetate to the solution—preferably in the clarifying vat before the extractor.

Thiocyanates are not thus reduced either by zinc dust or by sodium amalgam."—H. R. Edmands. *Monthly Journal of Chamber of Mines of Western Australia*, June 30, 1916, p. 143. (H. A. W.)

The Metallurgy of the Rarer Metals.—"In a paper presented before the American Institute of Chemical Engineers, at its Cleveland meeting, Prof. J. W. Richards of Lehigh University discussed the importance and future of magnesium, calcium, chromium and other metals. According to Prof. Richards, there are many metals which may be called the rarer metals, but the most interesting among these, both to the metallurgist and economist, are those metals whose compounds are relatively cheap and which command high prices because of the difficulty of their reduction. These are metals whose market prices may at some time be reduced anywhere from one-half to nine-tenths by improved methods of reduction. He said that if his paper had been written 30 years ago aluminium would be one of the metals that would be discussed, being in 1886 one of the rarer metals selling at $10 per pound. The silicon industry furnishes another example of great reduction in the cost of the metal. This, in 1900, was selling as a chemical curiosity at over $100 an ounce; now 10 cents per pound is a good market price for it.

Beryllium.—The speaker referred at length to the number of metals that at present command high prices, but which by improved metallurgical processes might be made very cheaply. These include beryllium, boron, magnesium, calcium, strontium, zirconium, molybdenum, barium, titanium, chromium and cerium (mixed metals of the cerium group). He said the present methods of reducing beryllium are tedious and costly and that it is not to be expected that this metal can be made cheaply until some one masters the direct electrolysis of the oxide, dissolved or suspended in a more stable melted salt, which is by no means an impossibility. He said this metal, being white, malleable and unchanged in air, with a specific gravity of 1·64, would make it particularly useful for objects where great lightness and permanence in air are the first consideration, with the cost secondary. He characterized it as a metal that will repay extended metallurgical research and minute physical and chemical study of its many properties.

Magnesium and Its Future.—Prof. Richards said that the metallurgist had not made a fraction of the progress that he should have made with magnesium. Although magnesium oxide costs only a few cents per pound, the metal sells for about as many dollars per pound and is scarce. But it is believed that, by improving the methods, the reduction of magnesium can be produced at 25 cents per pound. He said that while the war lasts, with its enormous demand for magnesium for military purposes, the price will remain in the dollars per pound, but with improved processes that are being developed he believes that after the close of the war, with normal industrial conditions, magnesium will sell at a price which will take it out of the class of rarer metals and put it among the common ones. As the price goes down its industrial uses will increase in geometrical proportion, and instead of the production being expressed in thousands of pounds per year it will reach thousands of tons. This will be one of the by-products of the war's stimulus to metallurgical industry.

The speaker said that the possibilities held out to the metal industry by reasonably cheap magnesium are extremely interesting, and that it is quite possible that alloys analogous to dur-alumin may be discovered, as strong as soft steel, with only 30% of its weight, which will find extensive use in aeroplanes and dirigibles. Such alloys may largely displace aluminium alloys, which are now used by the thousands of tons annually in the automobile industry, with a saving of one third in weight, which will compensate for the higher first cost. He predicted that the metallurgical use of magnesium will also be greatly extended by its lower price, such as for deoxidizing brass, copper, bronze, nickel and monel metal, since it is a much stronger deoxidizer than aluminium. In fact, aluminium has blazed the way into numerous uses for which magnesium, as soon as it becomes cheaper, will compete and replace its older sister. He predicted a large future for magnesium as one of the common metals of everyday life.

Calcium in Alloys and as a Deoxidizer.—Calcium strontium and barium were referred to as the trio of highly interesting elements, common enough in nature, but scarce and of high price because of the metallurgical lack of efficient and cheap methods of reduction. Calcium was referred to at present as a semi-rare metal which could be produced much cheaper by present methods if made on a large scale to fill a large demand. The principal trouble at present is in finding uses for the large production. He said its possible alloys with other light metals should be exhaustively studied, and that another large possible use is as a chemical purifying agent in melting and casting metals.

A small addition of metallic calcium might be used to reduce the amount of sulphur and phosphorus in steel, and other metals and alloys whose properties are damaged by sulphur or phosphorus may be similarly refined or improved. Barium was referred to as a metal that could be obtained in large quantities if its uses were developed. As barium is a good conductor, its use was suggested for electrical contrivance, and there are possibilities that its cost can be very materially reduced.

Growing Importance of Chromium.—The fact that the use of chromium in steel is rapidly extending to all varieties of extra hard and high-speed steel was referred to, and the paper stated that the use of pure chromium is limited by its high cost of production and our lack of knowledge as to how to handle it and its possible useful effects. For example, chromium electro-plating is white and durable and for many purposes may be superior to nickel and almost equal to platinum plating, but the technique of always getting perfect plating has not been mastered.

Ferrochromium alloy carrying high carbon (6% to 8%) is produced cheaply in crucibles, cupola furnaces, blast furnaces and electric furnaces. Low-carbon ferrochromium commands three to five times as high a price because of the difficulty of decarbonizing the raw product. The speaker hoped that a test would be made in the electric shaft furnace to see if it is not possible to produce directly from the ore a low-carbon product, and said the present prices—$100 and $500 a ton, respectively, for the high and low alloys would warrant a great effort in that direction.

Prof. Richards stated that the metallurgy of chromium is full of attractive possibilities and the usefulness of pure chromium in the field of alloys is only beginning to be scratched. The scratch, however, has proven very much worth while. The success of A. J. Rossi and the Titanium Alloy Manufacturing Co. in producing ferrotitanium alloy from the enormous quantities of titaniferous iron ore in northern New York and Canada was referred to, and the speaker said that if uses are found for pure titanium some other than electric furnaces must be used to reduce it. These methods of reducing pure titanium are, like its prospective uses, still in the future. The metal is now quoted at about the price of silver, and if the problem is properly faced it could probably be made as cheap as chromium."—Prof. J. W. Richards, paper before American Institute of Chemical Engineers. *Mining and Engineering World*, July 15th, 1916, pp. 93 and 94. (H. R. A.)

Electrolytic Zinc Dust.—"The sudden increase in the price of zinc dust after the beginning of the European war, owing to the cutting off of the German and Belgian supply, led to the conducting of some experiments on the possibility of its production on a commercial scale from solutions of zinc, and the substitution of zinc made in this manner for the zinc dust ordinarily used in the precipitation of gold and silver in the cyanide process. The production of electrolytic zinc sponge seemed the most feasible method of accomplishing this object, the sponge to be of such a nature that it would crumble to dust when dried. Sponge metal can be obtained from zinc sulphate solutions by the continual addition of a small amount of either copper or arsenic salts to the electrolyte. The objection to the use of zinc dust prepared by this method is the needless dilution of the bullion caused by the copper and the danger met in the handling of gold and silver precipitates when arsenic is used to produce the sponge. The preparation of zinc sponge is also possible from sulphate solutions by keeping acidity low and temperature high. Zinc oxide, rendering the solution slightly basic, is the most desirable chemical for maintaining this condition. It is subject to the objection that it is only slowly and slightly soluble in zinc sulphate solutions. The same objections apply to zinc sponge prepared from chloride solutions, except that the zinc sponge seems to be more inclined to be oxidised during drying. Sodium zincate solutions allow of the deposition of zinc sponge under a widely varying range of electrical and thermal conditions. Stirring of the electrolyte must be avoided. Current efficiencies of about 60% and zinc dust precipitating efficiencies of 70% to 75% are possible. There seems to be no difficulty in getting one pound of zinc dust from a solution of zinc with 3 kilowatt-hours of energy. Sodium zincate solution recommends itself because of its ease of preparation from caustic soda and zinc oxide, both of which are articles of commerce. The zinc tenor of the solution can be maintained either by the addition of more zinc oxide or by the use of zinc anodes, by which latter process spelter can be converted into zinc dust."—H. J. Morgan and O. C. Ralston.—*Australian Mining Standard*, Feb. 15th, 1917, p. 105. (H. R. A.)

Flotation Test on Antimony-Gold Ore.—"The ore from the Sliscovich mine (Alaska) contains Au 0·1—0·2 oz., and Sb 18—40% as stibnite very intimately intermixed with quartz. Concentration by gravity having proved a failure, the ore was tested on a Case experimental machine, the separation of the gold and stibnite by flotation being successfully accomplished under the following conditions: pulp ratio, 1 : 6; size of ore, −60 mesh; proportion of wood creosote 0·2% and of acid 0·3%. The flotation concentrate carried 84% of the antimony, and the tailing 80—100% of the gold."—E. R. Pilgrim, *Eng. and Min. J.*, 1916, *102*, 820. —*Journal of the Society of Chemical Industry*, Dec. 15, 1916, p. 1222. (A. W.)

Some Devices Used to Regulate the Flow of Oil in the Flotation Process.—"At the Inspiration Mill at Miami, Ariz., a bucket elevator with variable speed is used. At the mill of the Miami Copper Co., Miami, Ariz., the oil is contained in a barrel on a scale. The oil flows into a vat in which a float is so arranged as to keep the level of the oil constant. The outflow of the oil is taken care of by a regulated valve.

The appliance used at the mill of the Chino Copper Co., Hurley, New Mexico, consists of a vat, which is fed by as many faucets as there are oils used to make up the mixture used in flotation. Metal discs rotate vertically in this vat. They are immersed to a certain depth in the oil. The number of discs depends on the number of mixers to be supplied. On one side of each of the discs is a metal scraper of certain width, which scrapes off the oil from the disc. The oil scraped off flows through suitable pipes into pipes leading to the mixers.

The apparatus used at the new mill of the Vindicator consists of a vat holding the oil, in which rotates a cylindrical disc. As at the Chino, this disc is partly immersed in the oil. The scraper in this instance comes in contact with the cylindrical part of the disc, thus scraping off the required amount of oil. The number of discs used will depend on the number of mills to which oil has to be added for mixing."—*Metallurgical and Chemical Engineering*, Dec. 1, 1916, p. 620. (J. A. W.)

Laboratory Experiments on the Flotation of Ores.—"Experiments were undertaken to compare the value of different oils for flotation purposes under the same conditions. Those oils which are more or less miscible with water (*e.g.*, essential and pine oils, cresol, wood creosote) seem to be the best in regard to frothing properties; those that give an ephemeral, small-bubble froth yield a cleaner concentrate than oils which form a thick stiff froth (*e.g.*, fixed oils, coal tar, wood tar) though in the latter case the recovery may be greater. To get a clean concentrate it may therefore be necessary to sacrifice recovery, and *vice versa*. With a low-grade dolomitic lead ore, coal-tar creosote gave the purest concentrate (Pb 74%), oil of cloves giving the highest extraction. With a zinc slime (Zn 1·75%) pine oil gave a 50% concentrate, a mixture of creosote and refined tar a 46% product. Oils giving good flotation results were found to have a high di-electric constant. As the quantity of added oil increased above a certain quantity, the purity and quantity of concentrate decreased. The flotation concentrates submitted to screen analysis showed the largest proportion of gangue in the finest material."—C. Y. Clayton.—*Journal of the Society of Chemical Industry*, Nov. 30, 1916, p. 1160. (J. A. W.)

MINING.

Occurrence of Explosive Gases in Coal Mines.—"The following summary is based on the results of investigations made by the author in the northern anthracite basin of Pennsylvania and the southern part of the bituminous coalfield of Illinois, and on data previously obtained by other workers in Europe and America:—The gas emitted by freshly mined coal, whether *in situ* or in the laboratory, varies considerably in composition; in most cases it contains over 80% of methane, other constituents being carbon dioxide, nitrogen, and oxygen, the proportions of which are also very variable. These variations appear to be unconnected with any visible characteristics of the coal, and independent of the chemical constitution of the latter as expressed by the terms 'fixed carbon,' 'volatile combustible matter,' etc. The gas emitted at different stages of exposure, and from coal crushed to different degrees of fineness, also shows great variability in composition, for which absorption of air and subsequent combination with oxygen are doubtless largely responsible. Apparently, gas escapes from coal by percolation through the pores or interstices between the grains, and through small and large fissures, the emanation being thus dependent on the texture of the coal, the extent to which it is fissured, and the amount of pressure forcing the gas outwards. The most rapid and dangerous outbursts occur when the mining operation reaches a fissure or a body of shattered coal which constitutes a reservoir under high pressure, and when such a body of coal is thrown out in such large quantity that much of the gas is given off at once. Although occurring most often under the conditions named, or in places where the coal seam thickens and thins, such outbursts are not connected with any visible peculiarities of the coal, and no dependable means is yet available for detecting their proximity or preventing them. The pressure of gas in the solid coal has been determined in England, France, Belgium, Austria, and Illinois with results presenting anomalous variations, the suggestion that a precise ratio exists between pressure and depth of hole being negatived by most observations. In general, high pressure, if present at all, is manifested where the coal is most compact; and owing to leakage near the face, the higher pressures are found only in the deeper test-holes, the depth necessary for a high pressure depending on the compactness of the coal. As shown by the amounts given off by mining a definite quantity of coal, and by laboratory tests on coal samples, the volume of gas in coal is as variable as the pressure. While variation in the original volume of gas is no doubt related to the organic character and history of the coal and to other factors not yet ascertained, in many cases in the mines the coal containing the most gas, or gas with the highest pressure, does not have the most gaseous workings, the gas being emitted gradually over a long period and thus easily disposed of by adequate ventilation. Tests made to determine the amounts of gas given off by coals at ordinary temperature and at 212° F. (100° C.), in a vacuum, in the presence of various other gases, and in different periods of time, yielded a wide range of results without revealing any special relations. The volume of gas emitted generally increased with the time of exposure; and the rate of emission with the degree of fineness of the sample. At ordinary temperature coal yielded up to 5·5 times, and at 212° F. up to 8 times its own volume of gas; but the average yield at ordinary temperature was probably less than the volume of the coal employed, and however great the quantity liberated at first exposure, a long time always elapsed before the emission was complete. As regards the relation of methane accumulations to explosions in mines, deductions based on statistics are considered misleading, since most of the explosions on record are known to have been started by accidental ignition and many of the larger ones propagated mainly by coal dust, the controlling cause of most of the accidents being the human factor and not increased methane emanation due to atmospheric or other influences. Generally, fewer accidents occur during times of evident danger than when the need for precaution is less apparent." — N. H. DARTON.—*Journal of the Society of Chemical Industry*, Oct. 31, 1916, p. 1052. (J. A. W.)

WATER CONSUMPTION IN WESTRALIAN MINES.—"Water consumption at mines at Kalgoorlie, Western Australia, is as follows: Five plants treating a total of 69,942 tons of ore per month by the dry process used 202 gallons per ton; while four plants treating a total of 73,981 tons by the wet method consumed 190 gallons per ton. This water costs from 36 cents to $1.68 per 1,000 gallons. The consumption includes everything from drinking water to that used in the power-plants at the mines and mills, and for sluicing away the residue. Water is also used for spraying tailing-dumps. All of the fresh water is supplied from a reservoir 353 miles distant, pumped through 30-in. pipes."—*Mining and Scientific Press*, Nov. 20, 1915, p. 785. (G. H. S.)

[Comparing with Rand practice, an average taken over several leading Rand mines gives 410 gallons per ton milled, costing 1·6s. per 1,000 gallons.]

MISCELLANEOUS.

RESUSCITATION AFTER ELECTRICAL SHOCK.—"In a recent number of the *N.E.L.A. Bulletin*, Mr. W. P. Strickland, general inspector of the New York and Queen's Electric Light and Power Co., of New York City, says:—

"Recently one of our foremen, after climbing a pole, preparatory to stringing primary wires, received a shock that caused him to fall to the ground. It is inferred that in adjusting his belt and shifting his position, his spur cut out, and that, to save himself, he instinctively reached out and touched the wires carrying 2300 volts. When the other linemen and ground hands reached him, to all appearances the man was dead. One of the linemen, following instructions, immediately took hold of the ankles of the limp body, lifting it until the whole weight rested on the neck, and then letting it fall. He then took a pair of connectors, and hammered the soles of the injured man's feet without removing his shoes. Another lineman opened the man's mouth, pulled forward the swallowed tongue (which occurs in electric shock), and was about to begin the Schaefer prone method of resuscitation, when the man returned to life. He was removed to the hospital, and is alive and well to-day, though suffering severely from his burns. For the past year the writer has been teaching his men to strike the feet without removing the shoes in all cases of electric shock. Some years ago an accident occurred where a man came in contact with 6,600 volts, fell from the pole, and was restored to consciousness by this means, although he was terribly burned, and died three days later. Another accident that came to the writer's attention happened in New Jersey, when a man came in contact with a wire carrying 2200 volts. This man was struck violently on the feet, his tongue was pulled forward, and he was restored to consciousness before the arrival of the doctor."—*Electrical Review and Western Electrician.*

Abstracts of Patent Applications.

(C.) 92.16. Joseph Haywood Walton (1), Edgar Hugh Boyce. Means for patching the wearing surfaces of pulp pumps. 6.4.16.

This application refers to the method of patching the wearing surfaces of pulp with a cementitious substance capable of application in a plastic condition, which sets as a tough and somewhat yielding mass.

(C.) 115.16. William Blanks. Improvements in linings for the ends of tube mills. 5.5.16.

This application relates to improvements in end linings of tube mills, which consist in forging old shoe shanks into tapered blocks to form a series of concentric rings, which are wedged into place.

(C.) 305.16. Edgar Rouse Sutcliffe. Improvements relating to presses. 9.12.16.

This application is for a coal briquetting press of special design.

(C.) 306.16. Edgar Rouse Sutcliffe. Improvements relating to presses. 9.12.16.

This application is for briquetting press of special design.

(C.) 308.16. Walter Edward Kimber. Improved apparatus for atomising liquids, especially applicable for supplying water under pressure in a spray form for use with rock drills. 11.12.16.

This application relates to apparatus for atomising liquid in a closed receptacle by means of compressed air.

(C.) 292.15. John Robert Pratt (1), William Scott Duncan (2). Improvements in means for regulating or controlling the underflow from classifying cones and the like. 26.11.15.

This application relates to means for controlling the underflow from classifying cones, and consists of a modification of the means actuating that type of cone using a flexible diaphragm. The weights are replaced by a water cistern and a system of automatic valves.

(C.) 30.16. Bernard O'Connor (1), David Johnson (2). Improvements relating to filter presses and the like. 4.2.16.

This application is for detail changes in the pipe connections of filters of the vacuum type, and consists in cross-connections from the vacuum pumps to the suction mains, whereby the vacuum may be applied to both ends of the mains simultaneously, also to two boxes simultaneously.

(C.) 31.16. John James Robert Smythe. Improvements in skips and the like for inclined shafts, and means for tipping or discharging the same. 5.2.16.

This application refers to a method of dumping skips in inclined shafts. The wheels and axles are fixed to a frame on which the skip is carried, the skip being arranged to tip on an axle attached to it and carried in bearings on the travelling frame, which remains in normal position on the track. Projecting horns are attached to the skip, which on coming in contact with hooks provided at the tipping place cause the skip to turn over on its axle and discharge the contents of the skip. Arrangements are provided for putting these hooks out of action to enable the skip to pass over them without tipping if required.

(C.) 41.16. Wilhelm Mauss. Improvements in feeding water to hollow rock-drills. 15.2.16.

This application refers to the method of preventing leakage between a drill piston and a water supply tube passing into the same, which consists in maintaining air under appropriate continuous pressure between the piston and the tube.

(C.) 265.16. Gogu Constantinesco (1), Walter Haddon (2). Improvements in rotary motors actuated by alternating fluid currents. 27.10.16.

This application refers to the design of a rotary motor having one or more oscillating members actuated by an alternating fluid current driving a rotor in a constant direction, and is to be used more particularly in connection with the fluid wave transmission system covered by Patents Nos. 156/14 and 109/14.

(C.) 267.16. Gogu Constantinesco (1), Walter Haddon (2). Improvements in and relating to liquid wave transmission. 28.10.16.

This application refers to a method and means for cutting off the wave energy in a branch line by the regulation of a leak situated at any point on the branch line in a fluid wave transmission system. There are 10 claims in the application showing various means by which the object is to be attained.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Blyth, W. B., *to* c/o Blyth & Marriott, P. O. Box 626, Bulawayo, Rhodesia.

Boydell, H. C., *l/o* Gold Coast Colony; c/o Institution of Mining and Metallurgy, 1, Finsbury Circus, London, E.C.

Dennison, J. A., *l/o* London; c/o Anglo-French Exploration Co., Ltd., P.O. Box 2927, Johannesburg.

Gill, H. W., *l/o* England; Magadi Soda Co., British East Africa.

Lee, W., *to* Master Cecil Mine, P.O. Box 41, Bulawayo, Rhodesia.

Marriott, F. A., *to* c/o Blyth & Marriott, P.O. Box 626, Bulawayo, Rhodesia.

Pugh, D. W., *l/o* Johannesburg; Dynamite Factory, Modderfontein.

Wilson, R. A., *l/o* Rhodesia; Trydene, Sandgate, England.

APR 1 [illegible] 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. APRIL 1917. No. 10.

Proceedings
AT
Ordinary General Meeting, April 21, 1917.

The Ordinary General Meeting of the Society was held in the South African School of Mines Building on Saturday, April 21st, Prof. J. A. Wilkinson (President) in the chair. There were also present:—

15 Members: Messrs. J. Gray, H. A. White, J. Chilton, C. Toombs, F. Wartenweiler, John Watson, A. F. Crosse, J. E. Thomas (Members of Council), R. A. Cooper, A. King, G. Melvill, S. Newton, C. B. Simpson, A. Thomas, & T. P. Waites.

2 Associates and Students: Messrs. O. A. Gerber and D. W. Pugh.

6 Visitors, and Fred Rowland (Secretary).

MINUTES.

The minutes of the meeting held on the 17th March, 1917, as recorded in the March *Journal*, were confirmed.

GENERAL BUSINESS.

UNDERGROUND AMBULANCE SHIELD COMPETITION.

The President: I should like to announce that to-morrow the Competition for the Underground Ambulance Shield presented by this Society takes place, under the auspices of the South African Red Cross Society, at the Village Deep Mine, at 9 o'clock. Twelve teams have entered, a much larger number than in previous years. I shall be very pleased if any of the members present, or any of their friends, are able to be present, not only to see the work, but to give encouragement to it. After all, if this work is to be of any value to those for whom it is meant, it requires the utmost encouragement that can be given. It ought to appeal to those of you whose life is underground, and I hope therefore that all the members, who can come, will do so.

SUGAR FOR DUST FILTERS.

Mr. R. A. Cooper *(Member)*: As there is a good deal of difficulty just now in getting a clean and coarsely crystalline sugar for dust testing, it may be of interest to members to know, that it can be easily prepared by dissolving sugar in methylated spirits and recrystallising. For that purpose I take 1 litre of methylated spirits and mix with it 50 cc. of water, then warm the mixture with about 350 gm. of sugar until a saturated solution is obtained, filter the solution through a rapid filter and stand aside to crystallise. It is necessary to allow the solution to cool slowly and without any disturbance to obtain large crystals. One great advantage of this sugar is that a low "blank" is obtained when doing dust determinations—actually 0·0012 residue after dissolving, filtering and burning the residue—so that it is a great improvement on any commercial sugar.

The contents of each of the bottles shown were obtained from 1 litre of solution (200 gm. of sugar crystals). It is easy to get two crops of crystals in 24 hours—one during the day and one overnight. The actual size of crystal obtained is easily regulated by altering the rate of cooling. Usually it is necessary to crush the sugar slightly before using for sampling, exactly as is done when the usual "coffee crystals" are used. The sugar taken for crystallising is common white sugar from the grocers, but any other will do. It is cheaper to make crystals from common sugar than to buy special crystals, as the latter are usually about 2d. per lb. more expensive than the common, even when obtainable normally. Evaporation of the methylated spirits during the process may be reduced to a trifling amount by keeping the crystallising syrup in a closely covered dish.

After removing a crop of crystals from the syrup the latter is simply boiled up again with a fresh supply of common sugar over a water bath and the process repeated. It is necessary to have a fairly coarse grained sugar in a deep layer for sampling, because, if a very fine grain is used it offers too great a resistance to the suction of the sampling pump, and causes an error in the determination, either by back leakage of the pump valves, or, more usually, by the sampler commencing a fresh stroke with the pump before the suction of the previous stroke has been exhausted. Sugar is usually crushed to pass a screen about 10 mesh, sugar dust is removed by a fine screen, so that a product of varying crystal size is obtained, and the sugar in a sampling tube is usually slightly moistened before use to make it more retentive of dust.

Mr. Jas. Gray *(Vice-President)*: On the question of the size of the sugar, it was originally laid down that it should pass a 20-mesh.

The President: In connection with this matter of sampling dust in mine air, I should like to read an extract from the speech of the President of the Transvaal Chamber of Mines, delivered a few days ago.

"I may mention, that the possibility of any considerable advance in the problem of sampling mine air for dust depends on an improvement in the apparatus used to collect the dust for analysis. At present each sample of air is taken by means of an air pump and a tube containing sugar, a given quantity of air being drawn through the sugar tube, which collects the whole of the dust in the sample, the sugar being then dissolved and the dust separated and weighed. This method is accurate but necessarily slow, and renders it impossible to take sufficient samples in any mine to express numerically and with reasonable correctness the average dust contents of that mine. In other words, while the large number of samples taken by the dust sampling staff during each survey, when averaged, gives a fair indication of the dust conditions on the mines as a whole during that period as compared with any previous survey, the results for any particular mine are necessarily so few in number as to make them valueless as a criterion of the average conditions in that mine. Other methods of taking the samples have been considered, and in particular a microscopic method put forward by Mr. Kotze, the Government Mining Engineer, which in a rudimentary form has already been used in factories where organic dust is produced. The scheme is a promising one, and consists in causing a small measured quantity of dusty air to impinge through a fine orifice on a glass slide covered with some sticky substance, and then in counting under the microscope the number of particles that adhere. There is no doubt that to advance further in the determination of dust in air a simple and rapid method of sampling is required, so that by means of a great number of such observations it will be possible to determine numerically the average dust contents of each mine in a sufficiently reliable manner."

It is almost unnecessary to endorse the view that a physical method such as the one suggested in the above extract will, if perfected, lead to a far wider and more exact knowledge of the dust conditions than is possible under present conditions.

NOTES ON TREATMENT OF PILGRIMS REST ORE.

By Robert Lindsay (Member).

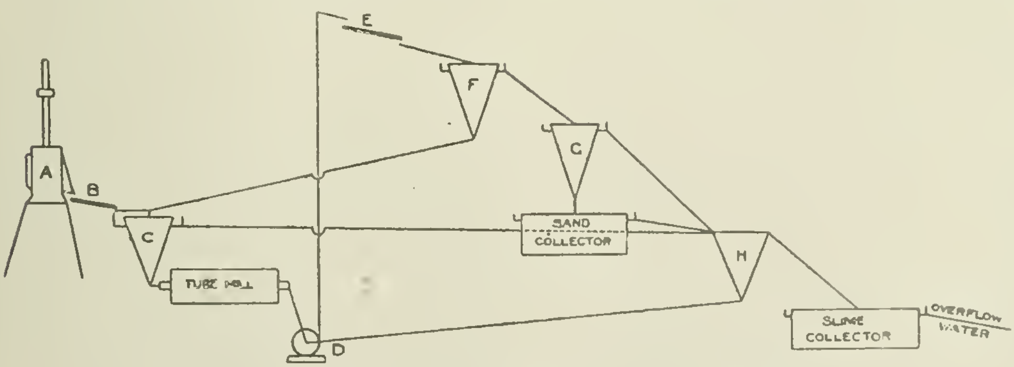
Introduction.—During the year 1916 the Pilgrims Rest district produced gold to the value of over £815,000, and forms, after the Rand, the most important goldfield in South Africa. It is said, that in the early stages in the history of these fields quite two thousand diggers were engaged in alluvial working, which yielded some £500,000 worth of gold. During later years, gold-bearing reefs were discovered and worked, with the result that alluvial occurrences now occupy quite a subordinate position, almost the entire output being derived from the numerous quartz reefs since discovered, and now the mining industry at Pilgrims Rest has become firmly established as the most important economic factor in the Eastern Transvaal, and the gold output has been more than doubled in the last ten years. The industry here affords direct employment to over 250 Europeans and over 4,000 natives. These figures, alone, however, do not reflect the real importance of the industry, since a considerable proportion of the general popu lation is indirectly affected by its fortunes, whilst, as already stated, these fields, next to the Rand, furnish the largest contribution to the output of the Union.

The Ore Deposits.—The oxidised ore treated by the Transvaal Gold Mining Estates, Ltd., at Pilgrims Rest may be described as deposits of vein quartz in more or less horizontal sheets embedded in the dolomites, and are associated with much ferruginous matter. Chalcopyrite ($CuFeS_2$) is only occasionally met with and appears to be only very slowly attacked by weak cyanide solutions. The copper exists principally in the form of the two carbonates —malachite, which is green, and azurite which is blue. This ferruginous quartz reef is rather coarsely honeycombed with cavities resulting from the oxidation and removal of the original iron ore. It is to be noted that a higher gold content and abundance of pyrite, decomposed or fresh, frequently go together, and the more earthy matter (*i.e.*, higher in hydrated iron oxide) or spongy the ore, the greater its value, which would seem to point to the introduction of the gold being directly dependent on the original pyrite. The richest portions are the more ferruginous varieties of the reef. It is interesting to note as indicating the extremely finely divided condition of the gold, that panning sometimes shows no colour while the assay values are good. Cyaniding or some other dissolving process is therefore essential.

Power Supply.—The Transvaal G.M. Estates' power requirements are obtained from the waterfall at Belvedere, some 19 miles north of Pilgrims Rest. The installation consists of three Francis turbines, each of 950 h.p., driving 750 K.V.A. 2,200 volt 3-phase generators at a speed of 750 revs. per minute. Two of the above units are run on load, with one as a stand-by. The average load on the station is about 750 K.W. The turbines are run under a head of 190 ft. The voltage from the generators is stepped up through transformers to 23,000 volts and transmitted at this pressure to central works (19 miles) on steel towers, the span being 360 ft. At the Vaalhoek Mine (10 stamps, tube-mill, etc.,) about seven miles south of the power station, and also at Central Works, the voltage is stepped down to 3,300 volts. For the smaller motors, the voltage is further reduced to 500, 220 and 120 volts respectively. The average number of units generated per month is 515,000, which is distributed as follows:—Vaalhoek 17,500 and Central Works 498,000. The total average cost per unit is 0·1d.

The Central Plant.—This consists of 60 stamps of 1,100 lb. running weight; three 16 ft. × 5 ft. 6in. tube-mills, each fitted with Osborne liner and Schmitt feeder; five sand collectors, and twenty treatment vats, each of 100 tons capacity; four slime collectors, and eleven treatment vats, 40 ft. × 12 ft., and the necessary storages. Capacity of plant is 13,000 tons per month.

Ore Treatment.—The ore is delivered to Central Mill from five separate mines in varying percentages. The mill bins and crushers are so arranged, that ore from any one mine can be kept entirely separate—thus enabling the management to keep in touch daily with the mill values from any particular mine. It also assists in locating an unusually high copper content, when that



Flow Sheet of Central Plant at Pilgrims Rest—Transvaal G.M. Estates, Ltd.
A = Stamp Mill; B = Amalgamating Plate; C = Diaphragm Cone; D = Pulp Elevator; E = Stationary Amalgamating Plate; F = Small Hydraulic Classifier; G = Hydraulic Slime Separator; H = Return Spitz.

occurs. The average value of current ore milled is about 9·5 dwt. per ton.

The ore is stamped through 60 stamps with a 500 screen, a duty of just over seven tons being easily maintained owing to the soft and friable nature of the ore. Lime is added at bins at the rate of 2 lb. per ton, and has a slightly beneficial effect on amalgamation. Amalgamation presents no great difficulty, an average recovery on the mill plates being 41·5%, at a cost of 1s. 10d. per ton, including preliminary crushing. This mill pulp contains 30% slime, and is passed direct to three 6 ft. × 4ft. 6in. tube-mill cones. The underflow from the cones, containing 30% moisture, and without any additional water, enters the tubes, while the overflow goes to spitzkasten (H), *vide* diagram. The gradings of pulp entering and leaving the tubes will be found in the next column.

Tube-mill liners are not a serious item owing to the soft nature of the ore. A recent liner lasted 520 days, but 470 days is a fair average. The tube-mill rock used is mostly white quartz picked out from the ore at the crushers and conveyed by tramway to the tube-mill ore bins and having an average value of 5 dwt. per ton. The average recovery from the five tube-mill plates is 10·5%, bringing the total recovery by amalgamation to 52%. The cost of tube-milling is 6d. per ton milled.

The pulp from the tube-mill plates flows to cone "F" in flow-sheet, the coarser particles returning to the tube-mill circuit, and the overflow to the slime separating cone "G," which is fitted with the Brazier washing device and Bayley regulating gate. The underflow from this cone goes direct to sand collectors and the overflow to spitz at "H," where any coarser sand is trapped and returned to the tube-mill circuit. The overflow from cone "H" goes to slime collectors.

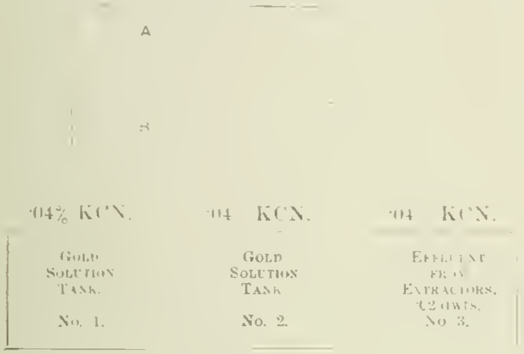
Sand Treatment.—The sand delivered from cone "G" is very clean, and there are few slimy lumps. The grading of the sand charge will be seen on the table attached to the flow-sheet. Sand caught is about 100 tons per day.

The objectionable constituent of the ore is copper, and it is necessary to use as weak cyanide solution as possible consistent with good recovery and reasonable cyanide consumption. The low strength of cyanide used renders a long treatment necessary. Lime is added to the top treatment vats at the rate of 6 lb. (of 60% CaO) per ton of

"500" SCREEN IN BATTERY—3 TUBE MILLS. Gradings of Pulp Entering and Leaving.

	A Screen.		B Tails.		C underflow		C overflow.		Tube Outlet.		F underflow		F overflow.		G underflow		G overflow		H underflow.		H overflow.		Sand Charge.		Sand Residue		Slime Residue.	
					Tube inlet																Slime chg							
	%	dwt.	%	dwt.	%	dwt.	%	dwt.	%	dwt.	%	dwt.	%	dwt.	%	dwt.	%	dwt	%	dwt.	%	dwt.	%	dwt.	%	dwt.	%	dwt.
+60	32·0	3·9	32·0	3·8	45·1	3·3	nil.	—	2·1	3·8	6·8	3·6	0·7		3·1	3·1	nil.	—	nil.	—	nil.	—	3·3	3·1	3·3	1·10	nil.	—
+90	14·7	7·4	14·7	5·0	28·8	4·8	1·0		11·1	3·2	23·2	3·2	6·0	3·1	23·0	3·7	1·1	3·4	2·5		nil.	—	24·6	3·7	24·6	1·15	nil.	—
+200	11·2	11·6	11·2	6·2	18·3	6·2	15·2	3·2	23·1	4·3	38·5	3·8	34·0	3·4	43·0	4·3	19·1	4·0	27·0	3·1	3·5	3·0	45·9	4·3	45·9	·82	3·5	·64
−200	11·5	33·9	11·5	10·0	5·8	12·2	23·8	8·5	19·7	8·0	21·8	6·8	22·3	6·0	20·9	6·5	33·0	6·0	35·7	6·0	26·6	5·0	22·4	6·6	22·4	·76	26·6	·57
Slime	30·6	6·2	30·6	4·8	2·0	5·4	60·0	3·9	44·0	3·5	9·7	3·7	37·0	3·5	10·0	4·1	46·8	3·0	34·8	4·5	69·9	4·1	3·8	4·2	3·8	·60	69·9	·46
	100·0	9·4	100·0	5·3	100·0	4·8	100·0	4·9	100·0	4·5	100·0	4·3	100·0	4·0	100·0	4·6	100·0	4·2	100·0	4·6	100·0	4·3	100·0	4·7	100·0	·88	100·0	·493

sand The strength of cyanide solution used throughout the sand treatment is 0·04% KCN. and the details are as follows:


A
B
·04% KCN.
·04 KCN.
·04 KCN.
Gold Solution Tank. No. 1.
Gold Solution Tank No. 2.
Effluent from Extractors. ·02 dwts. No 3.

TOP TANK A.

35 tons from tank No. 1.	Stand 4 hours.	Drain to tank No. 1.
35 tons ,, ,, ,,	Stand ,,	Drain ,, ,,
35 tons ,, ,, ,,	Stand 8 hours.	Drain to Extractors.
35 tons ,, ,, ,,	Stand ,,	Drain ,, ,,
35 tons ,, ,, ,,	Stand ,,	Drain ,, ,,
35 tons ,, ,, ,,	Stand ,,	Drain ,, ,,
35 tons from tank No. 2.	Stand 8 hours.	Drain to tank No. 1.
35 tons ,, ,,	Stand 8 hours	Drain ,, ,,

BOTTOM TANK B.

35 tons from tank No. 2.	Stand 8 hours.	Drain to tank No. 1.
35 tons ,, ,, ,,	Stand 8 ,,	Drain ,, ,,
35 tons from tank No. 3.	Stand 8 ,,	Drain to tank No. 2.
35 tons ,, ,, ,,	Stand 8 ,,	Drain ,, ,,
35 tons ,, ,, ,,	Stand 8 ,,	Drain ,, ,,
35 tons ,, ,, ,,	Stand 8 ,,	Drain ,, ,,
35 tons from Slime Storage No. 4.		Drain to Slime No. 1.

It will be seen, that only 27 of the solution pumped on goes to the extractor boxes, the remainder being by-passed to storages 1 and 2. The charges are allowed to stand for several hours after each complete draining The value of the charge does not decrease rapidly during the early part of the treatment, rather is it a steady decrease all the way through.

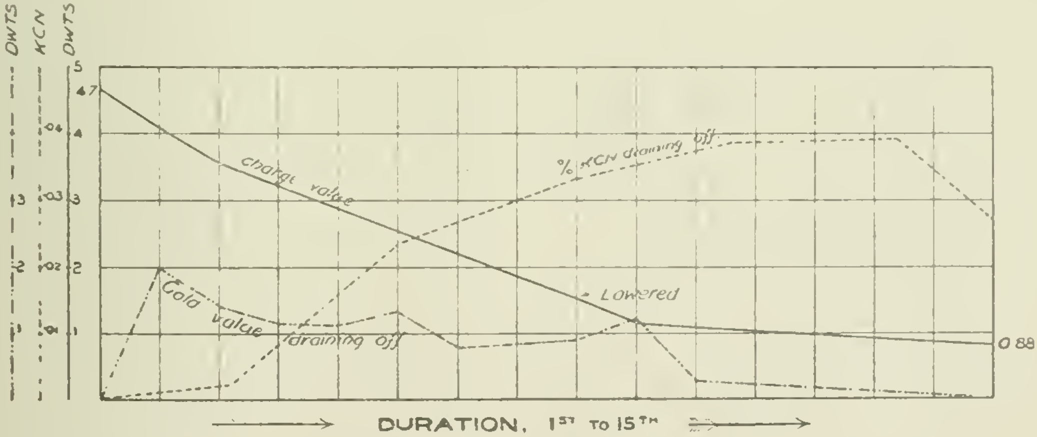


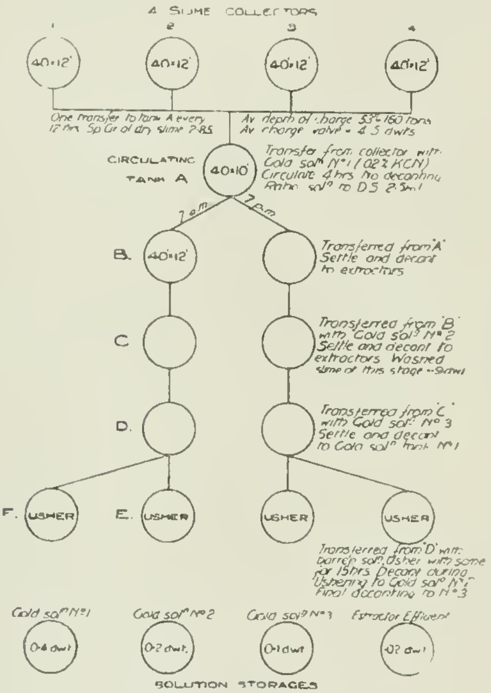
Chart Showing Slow Dissolving Action.

The value of sand last draining averages 0·06 dwt. per ton. Sand residues averaging 0·9 dwt., on regrinding, until 80 was –200, were re-cyanided, but did not give a lower residue than 0·7 dwt. The cyanide consumption is seldom under 0·8 lb. per ton and sometimes as high as 2·5 lb., according to the copper content of the ore. A preliminary wash with weak sulphuric acid to remove the copper is prohibitive in cost, the consumption of acid being about 30 lb. per ton owing to the presence of dolomite and iron oxide. The average recovery for the past 12 months was 83·0%, and the cost as follows:—

	Per ton sand. d.
White wages	7·39
Native wages	5·43
Workshops	1·63
Power	1·20
Cyanide	9·91
Zinc	2·98
Acids, etc. ..	2·22
Native food	1·69
Lime and other stores	6·60
	3s. 2·99

Slime Treatment —The slime caught is

about 320 tons per day. The treatment process followed may be described as a combination of the decantation and Usher processes. The following flow-sheet with notes attached makes the procedure clear:—


4 SLIME COLLECTORS
1
2
3
4
40'×12'
40'×12'
40'×12'
40'×12'
One transfer to tank A every 12 hrs. Sp. Gr. of dry slime 2·85
Av. depth of charge 5'3" 160 tons
Av. charge value = 4·5 dwts
CIRCULATING TANK A
40'×10'
Transfer from collector with Gold solⁿ No 1 (·02% KCN) Circulate 4 hrs No decanting Ratio solⁿ to DS 2·5 : 1
7 am
7 am
B.
40'×12'
Transferred from 'A' Settle and decant to extractors
C
Transferred from 'B' with Gold solⁿ No 2 Settle and decant to extractors Washed slime at this stage ·9 dwt
D.
Transferred from 'C' with Gold solⁿ No 3 Settle and decant to Gold solⁿ tank No 1
F.
USHER
E.
USHER
USHER
USHER
Transferred from 'D' with barren solⁿ Usher with same for 15 hrs Decant during Ushering to Gold solⁿ No 1 Final decanting to No 3
Gold solⁿ No 1
Gold solⁿ No 2
Gold solⁿ No 3
Extractor Effluent
0·4 dwt
0·2 dwt.
0·1 dwt
·03 dwt
SOLUTION STORAGES

— FLOW-SHEET OF SLIME PLANT

The slime residue averages 0·52 dwt., and the washed residue 0·43 dwt. Loss in dissolved gold = 4·5d. per ton of slime treated. Re-cyaniding the residue fails to extract more gold.

Instead of using sand filters as clarifiers for the solution from the slime plant, the solution is allowed to flow quietly into two settlers (18 ft. dia. × 5 ft. deep), the first having one, and the second two partitions of cocoa matting suspended from iron bars laid across the vats transversely to the flow. The matting is fastened to the sides and rests on the bottom. These settlers deal with 1,000 tons of solution per day for 16 months before requiring cleaning out. They are then cleaned out with a fire hose and are ready again for use in three or four hours. The average recovery from slime for the past 12 months was 87·5%, and the cost as follows:—

	Per ton slime. d.
White wages	5·62
Native wages	1·12
Workshops	1·15
Power	0·87
Cyanide	1/7·50
Zinc	2·37
Acids, etc.	2·49
Native foodstuffs	0·34
Lime and other stores ...	6·15
	3s. 3·58

Precipitation.—Cyanide solutions containing copper deposit this metal readily on clean zinc; the copper forms a closely adherent metallic film or plating, which after a time coats the zinc so completely that the precipitation of gold almost ceases, and here the lead zinc couple is used with advantage for cupriferous solutions. Lead-coated zinc does not precipitate copper so readily from working solutions as clean zinc, and the object aimed at is not to precipitate all the copper, but to keep the amount of copper in solution more or less constant. If the lead coating be too light, too much copper will be thrown down, and more zinc will have to be added to the extractors before clean-up is due, resulting in unnecessarily high consumption of zinc. The practice in dipping is to regulate the quantity of zinc dipped with the strength of the lead solution so that each 100 lb. of zinc carries 5 lb. metallic lead. That suits the copper content of the solution here and precipitates about one-half of the copper entering the extractors, while the gold value of the effluent is seldom above 0·03 dwt. even in the cold season. Increasing the cyanide strength as a remedy for bad precipitation is not recommended. It gives temporary relief, no doubt, by keeping copper in solution, but the gradual accumulation of copper in solution detrimentally affects extraction and the excess copper has to be got rid of eventually, either by precipitation or running some of the solution to waste.

If the soluble copper content of the ore should become abnormally high, it will be found advantageous to have uncoated zinc in the first compartment to precipitate a proportionally large amount of copper, leaving the remaining compartments of lead-coated zinc to precipitate the gold and a portion of the remaining copper. The first compartment of coppery zinc is taken out every 4 or 5 days and immersed in dilute acid for a few minutes, and returned to the box along with some new zinc to fill the compartment. There is an increase in zinc consumption, but the gold precipitation is good.

The precipitation of copper on zinc is, of course, accompanied by a regeneration of cyanide, thus:—

$$Cu_2(CN)_2 \cdot 4NaCN + Zn = 2Cu + Na_2Zn(CN)_4 + 2NaCN,$$

or

$$Cu_2(CN)_2 \cdot 6NaCN + Zn = 2Cu + Na_2Zn(CN)_4 + 4NaCN,$$

consequently the cyanide strength leaving the extractor box is always higher than that entering it, as shown in the following table:—

	Sand Boxes.			Slime Boxes.		
	% KCN	% CaO	Cu lb. per ton.	% KCN	% CaO	Cu lb per ton.
Entering ...	·032	·007	·12	·022	·008	·09
After 1st Compt. ...	·039	·008	·11	·025	·011	·07
" 2nd " ...	·044	·009	·08	·028	·010	·05
" 3rd " ...	·042	·010		·029	·010	
" 4th " ...	·040	·010		·028	·011	
" 5th " ...	·039	·011	·07	·028	·011	·04

The tendency of the copper to remain in the stronger solution of the sand boxes will be noted, the precipitated copper there being 41·7% as against 44·4% in the case of the weaker cyanide solution of the slime boxes with a lower copper content entering. One cubic foot of zinc is allowed per ton of solution per 24 hours.

The clean-up takes place twice a month. The top compartment only of each box is taken out and treated as usual with sulphuric acid. Bisulphate is not used on account of difficulty of transport and inconvenience of handling, the mine being about 10 miles from the nearest railway station at Graskop. When all the zinc has been dissolved, the copper is attacked by nitric acid, or with sulphuric and nitric acids together, which is cheaper than nitric acid alone, thus:—

With Nitric Acid only—

$$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 4H_2O + 2NO$$

189 + 504 @ 1/- per lb.

504/- = £25 4/- for 189 lb. of copper

With Sulphuric and Nitric Acids—

$$3Cu + 3H_2SO_4 + 2HNO_3 = 3CuSO_4 + 4H_2O + 2NO$$

189 + 294 + 126

= 62/- + 126/- = £9 8/- for 189 lb. of copper.

Over 700 lb. of copper are dissolved out every clean-up. The acids are added in the proportion of 1 part sulphuric to 0·44 part nitric acid, and the temperature should not be under 60° C. if copper is to be kept out of the bullion. The precipitate, kept in suspension by mechanical stirrers, is tested for the presence of copper after each addition of acid, so as to ensure no more acid being added than is absolutely necessary. When the copper is all in solution the vat is filled with water and a few pounds of size added to assist settlement, which usually takes place in five or six hours. The solution containing the zinc and copper is passed through a sand filter to catch any fine gold slime in suspension. The surface of the vat is skimmed every other month and the sand used as flux. The solution now flows through a stoneware pipe to two copper precipitating vats, which are filled with scrap iron. Any old iron is put into these, firebars, fire-doors, worn-out plates, battery screening, etc. Every four months the vats are cleaned out and the precipitate screened to keep out coarse iron. It is air dried, thoroughly mixed, sampled, assayed and bagged in sugar pockets at a cost of 25/- per ton. The following are the details of a parcel of this precipitate sent to England last July, and on which a nett profit of £600 was realized:—

COPPER PRECIPITATE.

Dry wt.	Assay per Ton.			Total Content.		
	Au.	Ag.	Cu.	Au.	Ag.	Cu.
Tons	oz.	oz.	%	oz.	oz.	tons.
8.171	10·99	123·79	40·95	89·802	1011·550	3·346

There is no gold or silver in the copper vat effluent, and only a trace of copper towards the end of the run. It is found that coarse iron gives a much purer product, and by using that exclusively it is hoped to bring the precipitate up to over 60% grade. The copper recovered is equal to 0·13 lb. per ton milled, and agrees fairly closely with the difference between the copper content of originals and residues, and is rather less than one-half of the copper content of the ore for that period.

The washed gold slime is filter-pressed and dried. Calcining is not found necessary after using nitric acid. The gold slime assays about 30% gold and is fluxed with 25% borax, 12½% sand and 12½% manganese dioxide. The bullion averages 850 fine. The average total recovery from the plant is 94%, and the cost 5s. 7d.

Elandsdrift Mine.—This mine, situated about 35 miles by road south of Pilgrims Rest, is equipped with 10 stamps and the necessary cyanide plant to treat 1,500 tons per month. There are no metallurgical difficulties whatever, 11·5% recovery being obtained from the mortar box in the form of nuggets and coarse gold. A further 60% is obtained by plate amalgamation, and the cyanide works recovers 91·25% from the mill pulp, bringing the total recovery to 97·5% from a milling value of 14·25 dwts. per ton.

Vaalhock Mine.—This mine, situated 12 miles north of Pilgrims Rest is equipped with 10 stamps, tube-mill and cyanide plant capable of treating 1,800 tons per month, and a proposition of quite different character to either of the foregoing mines. The ore is milled through a 400 screen and tube-milled, the grading of the final pulp being 90% − 90 mesh. The average recovery by amalgamation is 33%, but it varies from 28% to 42%. Sand treatment is affected detrimentally by the high and fluctuating copper content of the ore, and a cyanide consumption of 3·5 lb. per ton is considered normal. An extraction of 80% is obtained from sand, and 85% from slime. The total recovery for the past 12 months averages 89·04% from a milling value of 8·2 dwts. per ton milled. The same precautions are taken here as at Central Works regarding precipitation, only half of the copper being thrown down. The greater amount of copper present makes itself in evidence further down the extractors than at the Central, but the gold values of the effluents do not average more than 0·03 dwt. per ton. The writer's experience in cyaniding this ore appears to be somewhat similar to that of P. W. Gaebelein, recorded in the *Engineering and Mining Journal*, July 1, 1916, an abstract of which appears in our *Journal* of January last. Gaebelein, however, has to contend with the extraction of silver values as well as gold, necessitating the use of much stronger cyanide solution for good silver extraction, but he gives his normal total extraction as from 85% to 86% on a grade of $20 to $25 per ton, and states that this is reduced when copper appears to a detrimental amount.

The foregoing notes are submitted to the Society, not so much with the idea that they contain anything new, as with the object of inviting that criticism on which further progress may be based.

I have to thank Mr. R. A. Barry, General Manager of the Transvaal G.M. Estates, Ltd., for his kind permission to publish these few notes and data.

Mr. Andrew F. Crosse *(Past-President)*: I should like to propose a vote of thanks to the author for this interesting paper. I know the district, of which he speaks, well, and there is only one criticism I would like to make, namely, it would be interesting to have mineralogical analyses of the various ores; *i.e.*, the content of copper pyrites, iron pyrites, etc., because a cyanide man, in treating the ore, should have this knowledge. I brought up this point some years ago, and again to-night, and I think the information I ask for would be quite interesting.

Mr. H. A. White *(Vice-President)*: In seconding this vote of thanks I must express agreement with Mr. Crosse in the desirability of giving mineral composition of the ore. The copper might be in some form, which would admit of its removal by other than acid reagents. It would also be interesting to know exactly how the copper compounds act in the direction of decreasing extraction, and some hints might be obtained by experiment with coppery solution from one mine used for extraction on the clean ore from the other mine.

The President: I am not myself engaged in practical cyaniding, but this paper appeals to me as being one that should have some practical value. The nature of the problem, which has to be tackled in the Pilgrims Rest District is very different to the one we have here. As far as I know—cyanide officials here have not to deal with copper, in solution, though I have seen copper pyrites in banket ore, but if ever it should happen to be found here, then the information, which is given in this paper, will be of considerable value. I have much pleasure in putting the vote, which I am sure will be carried unanimously.

Mr. J. E. Thomas *(Past-President):* It may be of interest to know that we obtained over 5% of copper in the calcined gold-slime at the Simmer Deep, quite recently.

The President: The impression I have is that, speaking generally, the amount of copper in the banket of the whole of the Rand is practically negligible: If that is incorrect, I hope somebody will correct me.

Mr. Andrew F. Crosse *(Past-President):* I think that statement is correct.

The President: I am rather surprised to hear the statement Mr. Thomas has made, because I was under the impression that they did not have anything like that quantity.

Mr. J. E. Thomas *(Past-President):* We had trouble about three years ago at the Simmer Deep, and it has again cropped up recently: in October, November, December, and January. The copper caused a great deal of trouble in smelting gold-slime, but it has again disappeared.

The President: There was a similar trouble on a mine near the Simmer and Jack some years ago which was brought to my particular notice.

Mr. J. E. Thomas *(Past-President):* I remember that in 1897, when running the Van Ryn West as a separate plant we used the Siemens-Halske process, and that in the first four days of each month the lead sheets forming the cathodes were coated with copper and just as bright as a new penny.

Mr. G. Melvill *(Member):* In 1894, when working on a small cyanide tailing plant just below the old Wemmer Pottery, we found quite an appreciable amount of copper in the tailings. A preliminary water wash was pumped on to wash out most of the acid, and followed by a caustic soda solution and a weak cyanide wash. A 0·35 cyanide solution was then pumped on at intervals and followed by weak washes. The leachings through the zinc boxes soon showed the presence of copper, principally in the first compartments. This tailing must have originally come from the outcrop workings of the Wemmer, but where the copper came from was a mystery.

Mr. S. Newton *(Member):* I happened to be working in 1893 at the Wemmer Pan plant, and it was rather peculiar in treating the sand and slime to find, that we got gold precipitating from the solutions in a yellow form. One could place a handful of zinc shavings in the pipe entering the head of the extractor box and gold would precipitate on the shavings in the natural yellow colour. This is the only instance in which I have seen it occur. In my early days I used to be proud in showing people the yellow gold on the zinc in the extractor boxes, until it struck me that it might be vaseline from the plug cocks at the head of the boxes with which we used to grease them!

But, apart from that, this paper is exceedingly well written, and one that would take the average member, who is a cyanide manager, a little beyond Rand practice. I believe Mr. Crosse has brought up the subject once or twice at these meetings.

In speaking of copper, the same thing happened in Rhodesia. There were very few men who had experience of it, and the general practice was discharge to the veld as soon as the solutions became foul.

This paper is certainly a very interesting and instructive one, and we must thank Mr. Robert Lindsay for giving us such a valuable addition to our *Journal*.

Mr. Andrew F. Crosse *(Past-President):* If I may make one more remark, there is always copper in Black Reef ore. I would also mention that, at Frankfort near Pilgrims Rest, I put up a vat holding 3 tons of sand. Then I pumped a very weak solution round quickly by air lift, and obtained a bigger extraction in 24 hours, than they were obtaining in four days; simply by running this weak solution round with plenty of air. I think that was rather interesting.

NEW APPLICATIONS OF THYMOLPHTHALEIN AND NAPHTHOLPHTHALEIN, INCLUDING RAPID METHODS FOR ANALYSING LIMESTONE AND AMMONIUM SALTS.

By James Moir, M.A., D.Sc., F.I.C. *(Past-President).*

(Printed in Journal, February, 1917.)

Mr. Andrew F. Crosse *(Past-President)*: I am always very pleased to testify to any new method which is brought out by the members of our Society, and, I think, Dr. Moir has brought out a most valuable and interesting one. I have made quite a number of tests myself. Luckily we have very good limestone in the Transvaal; I have checked the older methods with his method, and find the latter very much quicker and very reliable.

SILICOSIS IN RATS IN A WITWATERSRAND MINE.

By J Pratt Johnson, M.B., B.S. (Lond.), D.P.H.(Oxon.).

(Printed in Journal, March, 1917.)

DISCUSSION.

Mr. J. Chilton *(Member of Council)*: In reading Dr. Pratt Johnson's excellent paper detailing the results obtained, by exposing mine rats to a dusty atmosphere, it is comforting to observe the length of time that exposure must cover, before definite silicotic results are obtainable. It is only after a period of seven months' constant exposure to silica dust that unmistakable signs of the disease are apparent. This is probably due to the fact that the dust conditions on the Simmer Deep Mine are not favourable for the development of phthisis. In the last two dust surveys the averages of the samples from this mine were 1·9 mgm. and 2·7 mgm. per cubic metre of air. Although the averaging of dust samples may not be open to the objection of undue precision, yet it gives a fair working idea of the dust conditions, as samples are only taken in localities where dust is likely to be found in considerable quantities. The author says, that it was decided to place the animals used in the experiments under the worst possible conditions in a mine, and with that idea, the animals were placed in cages at the top of a stope. Surely enough information has been collected to prove that the worst possible place would be the exit from a number of drives and raises where the finest, and therefore the most dangerous, dust is produced, both in drilling and in blasting. If the conditions that were present when the last two dust surveys were made had obtained during the whole course of the experiment, it is to be feared, that senility would have defeated silicosis. The danger of exposure to coarse dust produced by blasting operations in stopes may be considered as almost negligible, as this increases in proportion to the fineness of the particles. It is probable, that more definite results would have been produced in a much shorter period if the experimental station had been better situated. However, as the Simmer Deep Mine is intended primarily to produce gold, and not silicosis, the lack of dust must give great satisfaction to the miners, however annoying it may be to the doctors.

In 1912 the Iron and Coal Trades Review* published an account of a number of experiments that were made by Dr. J. M. Beattie on the effect produced on the lungs by the inhalation of coal dust and other dust. This work was undertaken at the request of the Home Office, when stone-dusting was advocated as a preventive in coal dust explosions. The results produced were similar to those observed by Dr. Pratt Johnson, but the exposure in the most lengthy experiments only covered a period of 65 hours. In these observations 39 guinea pigs were used. They were exposed on the first day for half-an-hour to a dust-laden atmosphere, on the second and third days there was no exposure, on the fourth day exposure for one hour, on the fifth day for 1½ hours, on the sixth and subsequent days for 2 hours. In each week there was an exposure for five days and no exposure for two days. Some of the animals were then taken out and allowed to live in the ordinary air till the end of the experiment. During the time of exposure to dust, the animals were confined in specially constructed boxes, others were exposed in a tent and had only to withstand the dust that escaped from the special boxes. The experimental results were as follows:—

I. Exposure for 21 hours in specially constructed boxes.—A comparison of the microscopical sections of the lungs of the guinea pigs which had been inhaling coal dust, shale, and stone rich in silica, showed that with coal dust and shale there is moderate degree of change from the healthy lungs, whereas with the silica there is a well-marked increase in the fibrous tissue with a corresponding diminution in the air-containing, and therefore in the functioning, tissue of the lung. In the section the particles of coal, shale, and silica can be seen in the air spaces, in the fibrous tissue septa between the air spaces, and in the lymphatic channels and elsewhere in the lungs. At the places where they are lodged there is a moderate degree of dilatation of the blood-vessels and also a definite increase in the number of cells. The new cells are derived by multiplication from the pre-existing cells and are those from which the new fibrous tissue is eventually formed. These groups of cells therefore are the first indication that we have that new tissue is being formed and the direct evidence that the inhaled dust is causing irritation of the lung tissue. The degree of this cellular tissue varies with the irritant. Silica seems to produce a considerable increase of the cells, and transition stages between the original cells and the fibres of fibrous tissue to which they give rise can be made out

---

* "The Effect produced on the Lungs by the Inhalation of Coal Dust and other Dusts."—J. M. Beattie, *Iron and Coal Trades Review*, Aug. 2, 1912.

II. Exposure for 65 hours in specially constructed boxes.—A comparison of microscopical sections at this period shows similar changes to those seen after 21 hours' exposure, but the changes are more intense in degree and more widely spread over the lungs. The lungs appear more solid and the air spaces are obliterated to a much greater extent. The increase in the cells is more marked, the transitions between them and the fibres and fibrous tissue are more evident. In the areas in which the dust has accumulated the formation of new fibrous tissue is quite marked. With exposure to silica dust the fibrosis at this period is very marked, and in certain area the alveolar structure is completely lost.

III. Exposure for 65 hours in a tent.—In this experiment the atmospheric conditions were similar to those to be found in mines and grinding shops. A comparison shows that the changes are of the same nature but very different in degree. The particles of dust can be seen both in the air spaces and in the fibrous tissue of the lung. There is dilatation of the blood vessels in the neighbourhood of the dust accumulations, but comparatively little increase in the number of the cells. Fibrosis cannot be said to have occurred at all, though the indications are that with a longer exposure it would be produced.

It seems that these experiments prove that the wider nasal passages of the guinea pigs render them more suitable objects for dust experiments, though their well known susceptibility to tubercular infection is a drawback. It seems desirable that further research should be made, and horses and mules that have worked underground might form the subjects of more extended examination and experiment.

A number of experiments should be made to ascertain the effect of the sudden increase or decrease in the air pressure that is felt while travelling swiftly through deep level shafts. It is possible that this may have some effect in destroying some of the delicate structures of the lungs, producing a modified form of the well-known caisson disease, and contributing to the final destruction of the lungs.

As far as dust-preventing devices are concerned the writer feels that little further progress is possible. When our dust samples are reduced to two milligrams it will probably be found that chasing the last elusive milligram will not meet with much success, but there are still directions were progress can be made. One way is by a re-arrangement of working hours. At present most mines work 16 hours out of the 24 having two shifts, with an interval of four hours between each shift. Surely the most suitable arrangement would be to allow a long interval of eight hours after the blasting shift so that the mine could be thoroughly cleared of dust and fumes before the next shift is lowered. This can only be done in mines that blast once in 24 hours, but as many do this already little hardship would be felt in making the whole of our mines adopt this excellent arrangement.

The delaying of blasting in working places, near shafts, travelling roads, and waiting places where persons are particularly exposed to dust and fumes is another reform that is necessary in many mines. In many cases blasting should not take place till every person except the blaster is out of the mine.

Finally, let me thank Dr. Pratt Johnson and his worthy colleagues for their efforts in producing this paper, which deals with a subject that has been neglected for some considerable time.

The meeting then terminated

Contributions and Correspondence.

COMPARISON OF STAMP MILLING COSTS BETWEEN CALIFORNIAN AND NISSEN STAMPS AT MODDER B.

Referring to Mr. H. A. White's remarks, published in the February *Journal*, page 128, on the above subject, he appears to have overlooked the footnote in regard to the respective ages of the plants during the periods over which the figures I submitted were obtained. This note clearly states that the respective ages of the plants were approximately equal. In other respects the comparison rather favours the Californian stamps, as the cost of stores and materials had increased considerably in 1915.

After Mr. White's candid acknowledgments regarding the economic advantages of the Nissen stamps, it would be labouring the matter to do more than to point out that the figure 8·118d. refers to the average cost of stamp milling at Modder B. for the whole year 1915, whereas the figure 8·754d. happens to be recorded for one month only, namely, November, 1914—that particular month incidentally coinciding with the introduction of the new units.

Mr. White evidently wishes it to be inferred from the figures quoted that the Nissen stamps proved more expensive to operate than the Californian. In this he is particularly unfortunate, in view of the fact that the average milling cost over the three months preceding the starting of the Nissens was 9·3d. per ton on a tonnage basis of 39,300. From this figure—without admitting the correctness of such an assumption—the opposite would appear to be the case.

The opportunity to make a comparison of this kind, under ideal conditions, rarely occurs on our mines, experimental work invariably having to be subordinated to the exigencies of profit-making. However, something approaching the special conditions enumerated by Mr. White obtained at the City Deep, Nissen *versus* Californian stamp trials, details of which appeared in this Society's *Journal* in October, 1911, from which it will be seen that in trials 3 and 6, crushing the same ore through 3 in. mesh, amongst other advantages, the screen grading of the pulp showed slightly in favour of the Nissen stamps.

K. L. GRAHAM.

April, 1916.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

INVESTIGATION OF THE CHIEF METHODS OF DETECTING HYDROCYANIC ACID.—"The relative delicacy of the principal tests for hydrocyanic acid was determined on 10 cc. portions of solutions of 98·5% potassium cyanide. With a 0·01% solution (0·000393 gm. CN), a N/20 solution of silver nitrate and 20% nitric acid still produced a precipitate; the limit was reached with a 0·0001% solution (1 pt. HCN in 245,000), when the turbidity was visible only when viewed through a column 12 cm. high against black paper. In this test, it is advantageous to use an excess of silver nitrate. In the Prussian blue test, a precipitate was obtained with a 0·01% solution, but only a coloration at greater dilutions. The most dilute solution which gave the test was 0·001% (1 pt. HCN in 24,500). The conversion of cyanide into ferrocyanide is probably incomplete.* The identification as ferric thiocyanate is possible with a 0·0001% solution. The test was performed by adding 3 drops of ammonium sulphide and 2 drops of N/1 caustic soda to 10 cc. of the cyanide solution, evaporating to dryness on the water-bath, dissolving the residue in water and 3 drops of N/1 hydrochloric acid, and adding 5 drops of a 1% ferric chloride solution. The addition of a 15% caustic potash solution and a few cc. of a cold saturated solution of picric acid, produces a red coloration, but the limit is reached with a 0·01% solution of cyanide. The test is uncertain and is not recommended. The presence of hydrocyanic acid is indicated by the production of a blue colour on paper steeped in a 4% guaiacum tincture and 0·25% copper sulphate solution, or, better, in the liquid itself: but a 3% solution of guaiaconic acid and a 1 : 1000 copper sulphate solution is to be preferred. The weakest solution that gave the reaction was a 0·00001% solution (1 pt. HCN in 2,450,000). Certain other substances, *e.g.*, ammonia and cigar smoke, however, produce the same effect."†—G. ANDERSON, *Journal of the Society of Chemical Industry*, Oct. 31, 1916, p. 1083. (J. A. W.)

ELECTROLYTIC DEPOSITION OF BRASS.—"The separation potentials of copper and zinc from complex cyanide solutions were determined for current densities up to 0·01 amp. per sq. cm., and the influence of various additions to the bath, as also the influence of varying concentrations of the CN and OH ions, on the appearance of electrolytically deposited brass, determined. The experiments showed that for the deposition of brass the cathode potential must closely approach that necessary for the deposition of zinc from cyanide solutions. Whilst in potassium-copper cyanide solutions which contain at least 2KCN to 1CuCN, and therefore presumably contain the salt $K_3Cu(CN)_4$, the cathodic copper separation is accompanied by considerable polarisation, it becomes, at least with small current densities, almost reversible in solutions of the salt $KCu(CN)_2$. If increasing quantities of KCN are added to the latter solutions, the polarisation increases largely, long before all the CuCN can be present as $K_3Cu(CN)_4$. Also the presence of $K_2Zn(CN)_4$ in

---

* See Moir and Gray, this *Journal*, June, 1910.

† See Moir, addendum to paper, October, 1910.

$KCu(CN)_2$ solution causes strong polarisation of the copper separation, whereby there is brought about, just as in the solution of $K_3Cu(CN)_4$ and $K_2Zn(CN)_4$, a rise in the separation potential of the copper nearly up to that of the zinc, and as a result, electro-deposition of brass from the solution takes place. The separation potential of copper from cyanide solutions can be raised considerably by allowing the solutions to stand and by heating them. It is suggested that this result is due to changes in small quantities of colloidal material. If so, the polarisation of the cathode depends in these cases on continually renewed surface layers (mechanical passivity of the cathode)."—A. Hönig.—*Journal of the Society of Chemical Industry*, Sept. 30, 1916, p. 967. (J. A. W.)

The Structure of Coal.—"Suitably prepared transparent sections of coals reveal under the microscope the fact that different parts of the coal substance are composed of different materials. The authors have undertaken the further separation and examination of the different parts of the coal substance, aiming at an ultimate correlation of definite morphological tissues or portions of tissues of the original plants with specific chemical substances now in or yielded by coal. When various coals are treated in a suitable manner, certain vegetable débris, such as wood, spores, and cuticles, can be separated, and from some varieties of coal sufficient of each (botanically) distinct material can be obtained to enable a thorough chemical examination to be made. For example, the authors have obtained a supply of pure cuticle, freed from all other débris of the coal substance, sufficient to allow of a study of its behaviour under different modes of heat-treatment, from which the products of its destructive distillation can be determined and its chemical constitution deduced."—M. C. Stopes and R. V. Wheeler.—*Journal of the Society of Chemical Industry*, Oct. 16, 1916, p. 1001. (J. A. W.)

Influence of Iron Pyrites on the Oxidation of Coal.—"Experiments are described showing that iron pyrite has a minor effect on the oxidation of coals, and its presence cannot be ignored, even though non-pyritic coals may be amongst those most liable to ignition. A difficulty is experienced in drawing conclusions from the percentage of sulphur in a coal, as pyrites disseminated throughout a coal in microscopical particles will act more effectively than larger quantities of nodular pyrites. Even though samples be drawn from the same seam, it is almost impossible to make inferences from analyses, as great differences may exist in the physical conditions of occurrence. A fault, or a poor roof, may have, it is stated, a more predominating influence than the percentage of sulphur on the ignition of the coal."—T. J. Drakeley.—*Journal of the Society of Chemical Industry*, Oct. 16, 1916, p. 1001. (J. A. W.)

Paper Making Materials from South Africa.—"Tambookie grass (Cymbopogon Nardus var. vallidus) grows extensively in the Transvaal, particularly in the northern parts. The sample exampled ranged in length up to a maximum of 5 ft. 6 in., with a diameter of about ⅛ in at the base. On digestion with caustic soda tambookie grass yields 37·1% of an easily bleachable pulp (dry pulp referred to air-dry material), showing an average length of fibre of 0·081 in., and is considered to be well adapted for paper-making and to have a value higher that that of Algerian esparto. Papyrus is found in the St. Lucia Bay districts of Zululand and samples of this reed have been compared with those obtained from East Africa and the Sudan. It is easily digested with caustic soda and gives a good bleaching pulp, but the yield of pulp from the South African variety is somewhat lower than from those obtained from other parts. In the case of both these South African materials, it is considered that export in the raw state would not be profitable on account of freight, but they could be converted into half stuff for export or for the manufacture of paper locally."—Imp. Inst.—*Journal of the Society of Chemical Industry*, Oct. 16, 1916 p. 1008. (J. A. W.)

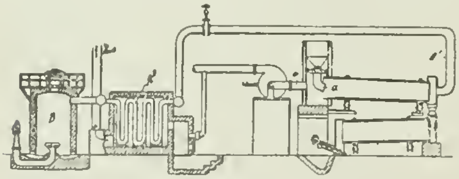
Gasoline Standards.—"The U.S. Bureau of Mines has, at the request of the Federal Government of the District of Columbia, prepared tentative specifications for gasoline, which have been submitted for criticism to refiners, motor engineers, and others, with a view to issuing final specifications. The specific gravity test is not included in the specifications. The requirements laid down in the draft are that the gasoline and its combustion products should not have a strong or disagreeable odour; the gasoline should be free from water, sediment, acid, sulphur, etc., and should not contain an excessive percentage of unsaturated hydrocarbons, nor too high a percentage of highly volatile products which tend towards excessive evaporation losses and unnecessary danger in handling and storage. The gasoline should not contain any considerable percentage of heavy or non-volatile constituents which prevent the atomisation into engine cylinders of a mixture that can be completely burnt. The limiting percentages of the constituents mentioned will be laid down in the final specifications."—*Journal of the Society of Chemical Industry*, Dec. 15, 1916, p. 1209. (J. A. W.)

A Remedy for Slippery Iron Floors. "Writing to the American Machinist, Mr. W. A. Lailer says:—In one part of our shop we have installed a large area of sheet iron floor-plates that were entirely satisfactory until the corrugations wore off, after which the smooth-worn plates gave considerable trouble owing to several nasty falls of the men that resulted the trouble being enhanced because of the presence of oil and grease. Roughening the plates by means of chipping was tried, but this could not be done very satisfactorily nor without excessive wear on the plates It then occurred to us to try to corrode the plates slightly as often as necessary, to prevent them from becoming too slippery. Since a deep rusting effect was not desired, because of excessive eating-away of the plates, we arranged to take care of it in the following manner: We take a small amount of powdered salammoniac, which is used as a corroding agent in our work, and mix it up thoroughly with a large quantity of fine sand. This mixture is then sprinkled over the floor so that all parts are covered, and then the whole mass is watered, using an ordinary sprinkling can and left to lie over night. In the morning the sand is swept up, a rust coating being produced by the action of the salammoniac that will last for several weeks, after which the process is repeated. We found that this method involved less time and cost and was more effective in eliminating danger from slippery iron plate floors than any other of which we have read."—W. A. Lailer.—*Indian Engineering*, Nov. 11, 1916, p. 315. (J. A. W.)

METALLURGY.

Removing Iron from Tin Ores.—"Iron is one of the most unwelcome admixtures in tin ores, since it is reduced to the metallic state in the smelting of the ores in the calciner or furnace, or is dissolved in the tin bath and causes losses of tin owing to the formation of 'hard heads;' generally speaking, as much tin is lost as there is iron contained in the ore. In order to reduce this drawback, it has been proposed to remove the iron from the ores in different ways, as by mechanical dressing, magnetic separation, and especially treating the concentrates with chemical solvents, for example hydrochloric acid. The ores contain the iron in the form of oxides or sulphides which by the roasting operation are converted into oxides soluble only with difficulty. On the other hand, lixiviation will produce compounds which are attacked only slightly even by concentrated acids, and therefore the final product obtained still contains a certain proportion of iron.

A better extraction of iron in the lixiviating of tin ores has been proposed by Günzel von Rauschenplat of Steglitz, Germany. By his treatment, the higher iron oxides of the original (of if necessary roasted) ore—in some cases after a preliminary concentration by any approved dressing process—are converted into products readily soluble in acids, for instance into Fe_3O_4, FeO, or Fe. For the reduction of these higher oxides, any of the customary reducing agents may be employed, for instance solid coal, carbon monoxide or hydrogen, taking care to keep the temperature so low that the cassiterite is not attacked at all or but incompletely, so that there will be present a tin-oxygen compound insoluble in acids. Gaseous reducing agents are preferred, since with them it is easier to watch the reduction and to prevent contamination by ashes. For hastening the reduction, temperatures lying between 300° and 500° C. are employed, according to the nature of the ore. With these temperatures, the major part of the iron is obtained in the form of FeO, and only a small proportion in the form of metallic iron or Fe_3O_4.



Removing Iron from Tin Ores.

For the extraction of the iron from the reduced ore, an aqueous acid solution is used, for instance of hydrochloric acid or of sulphuric acid, the reduced product being treated in the well-known manner, say on the counter-current principle, if necessary with heating of the lyes or preferably hydrochloric acid gas. The dry reaction product is treated with this acid at temperatures lying between 400° and 500° C. The iron is distilled in the form of volatile chloride.

The accompanying drawing shows apparatus suitable for carrying out the process. The ore, after being crushed to a fineness of from ½ to 5 millimeters is fed at (A) into a revolving furnace, which also receives a supply of reducing gases, such as producer gas, from a producer (B) the hydrogen coke-oven gas, or blast-furnace gases, are admitted through a pipe (A′) at the lower end of the revolving furnace or drum. This drum and the material are heated either externally, or as shown by preheating the reducing gases on their way to the drum, for instance in iron superheater tubes (A″).—*Mining and Engineering World*, Dec. 2nd, 1916, p. 954. (H. R. A.)

Alloy Steel Castings.—"Mr. David Evans, of the Chicago Steel Foundry, in a paper submitted for discussion to the American Foundrymen's Association, dealt with the function of different alloys added to steel. Titanium is really not an alloy, as it disappears entirely when added to the charge. Its value is entirely as a flux. It is used in several different forms depending on the process used by the steelmaker. Assuming that the steel is ready for the addition of the alloys, the 50% ferro-silicon is first added, followed immediately by the titanium, 4 to 6 lb. of the latter to a ton of steel being recommended. In open-hearth practice from six to eight minutes should elapse between the addition of the titanium and the pouring of the first mould, but in converter practice the time may be reduced to three or four minutes, which is sufficient for the slags and oxides to rise to the surface. The oxidation of titanium is a heat-producing reaction, so there will be no danger of chilling the steel by holding it for a few minutes in the ladle. In Bessemer practice the steel usually comes from the converter too hot to be poured at once, and a few minutes' wait is necessary, whether alloys are added or not. Titanium has proved itself a safer deoxidiser, as in the use of aluminium the tendency on the part of the pouring gang to use too much often results in the formation of alumina in the finished steel. There is an erroneous idea among some steel men that titanium prevents the formation of blow holes and piping in ingots. Its action is to prevent the formation of a number of blow holes throughout the ingot and to concentrate all of them in one place near the top. It is of great benefit in pouring thin sections where clean, hot metal was especially desired, and a maximum of strength required. The high price of and great difficulty in securing aluminium during the past year or so have done much to establish titanium in the steel foundry as no mean substitute. As regards vanadium, Prof. Arnold's discovery, in 1900, that 1·25% carbon steel with 3% vanadium would cut 75% more than the same steel with 3% tungsten marks the former alloy's real entry into metallurgy. Steel is improved by the addition of vanadium, but the full value will not be realised unless the steel is properly annealed. When ferro-vanadium is added, it goes immediately into solution. Through its affinity for oxygen and nitrogen it combines with those gases, when they are free, or united with elements by a bond weaker than that of vanadium. This deoxidising effect, however, is purely incidental, and where it takes place to such an extent as to cause excessive loss of the alloy in the finished steel it is an indication that the steel was not properly deoxidised in the first place. To this extent it performs the same office as titanium or aluminium, but is far too expensive to be used for this purpose alone. The practice seems to be fairly uniform among steel founders to add 0·10% to 0·20% of vanadium. It is claimed that it has a peculiarly intensifying effect on the other elements in the steel, or on alloys added, such as chromium, nickel, tungsten, etc."—DAVID EVANS.—*Iron and Coal Trades' Review*, Jan. 12, 1917, p. 42. (E. M. W.)

MINING.

HOURS OF WORK, ETC., ON TRANSVAAL MINES.—"It is generally admitted that the single shift system is a step in the right direction. At some mines which are not yet in a position to adopt this system every effort is being made to get on to this basis as soon as possible. There is no need to lay further stress on the great importance of this—the main step to economic mining.

It is well known that only a proportion of actual time underground is spent on productive work, and it is the object of this report to recommend ways of increasing this proportion.

The time lost varies with the class of work performed, but is greatest in the case of machine stoping.

The subject will be considered under the following heads:—

(*a*) Transport of men and material.
(*b*) Machine stoping.
(*c*) Hand stoping.
(*d*) Tramming and shovelling.
(*e*) Hoisting of rock.
(*f*) General.

Transport of Men and Material.—There is no doubt that the governing factor with regard to facility and rapidity with which men and material can be handled depends largely on existing conditions on each mine. It will, however, be found in many instances that, with an inappreciable outlay, modifications of existing plant might be made which would save a considerable amount of time and energy, for instance:—

The installation of large cages to carry from 60 to 80 men.

The use of trolleys specially constructed for the easy and rapid transport of large quantities of timber, rails, and other material, with suitable arrangements for the speedy handling of same.

The installation of underground drill sharpening and other shops to obviate unnecessary handling; efficient arrangements for dealing with all steel underground. (It is recommended that special trolleys be used for each working level, and that a proper system of checking steel, both inwards and outgoing, be introduced.)

The provision of facilities for cleaning out pump sumps.

The methodical organisation of hoisting time and the prevention of individuals from taking liberties which infringe the recognised time-table.

Machine Stoping.—Machine stopers—both white and coloured—spend little more than half their time underground in actual drilling. Several suggestions have been made to increase the drilling time.

One is, that a blasting shift should be introduced, to enable a machine stoper to drill up to the end of his shift, at the expiration of which pulling down and blasting will be undertaken by another man. Theoretically, there seems to be some value in this suggestion, but it has not proved a success in the past where tried.

Another suggestion is, that, where two shifts are worked, the practise at present found successful on some mines of running two drilling shifts consecutively with a single blasting shift at the end of the second drilling shift should be adopted.

A third suggestion is, that an extra incentive, to take the form of a bonus on footage drilled or fathomage broken, be given to machine boys. If native machine stopers could be induced to remain at their respective mines for longer periods, so as to enable them to understand such systems and the benefit they would derive therefrom, the standard of efficiency of machine stoping would be raised.

Hand Stoping.—The custom of allowing hammer boys to leave work and return to the Compound after completion of their task is probably a greater incentive to work than the money paid.

Two important points to bear in mind whilst considering this question are the vast difference in the drilling ability of boys, which varies from 30 in. to 72 in., and, owing to this variation, the difficulty of carrying benches in a stope to suit all the boys in a gang.

To overcome this difficulty the gangs might be made up of boys of similar ability, classified as follows:—

Learners.
Boys able to drill 30 in.
Boys able to drill 36 in.
Boys able to drill 42 in.
Boys able to drill two holes.

It is felt that the system of allowing boys to leave the mine before having done eight hours' work is wrong, but it is a custom on the Rand, and one which will be very difficult to alter.

Some device may be found whereby it will be possible for a hammer boy to drill more than he does to-day without the expenditure of greater energy, and this will necessitate the breaking down of the custom referred to.

Tramming and Shovelling.—It is considered that the efficiency of tramming and shovelling on these fields is low, owing to the type of boy employed on this class of work and to the day's pay system in vogue. Tramming and shovelling boys should be given as much incentive to work as boys of any other class, and wherever possible it is recommended that they be put on piece-work.

The type of truck has a great deal to do with the tramming efficiency, and the use of trucks of larger capacity, fitted with a more modern type of wheel, is suggested.

To assist efficient tramming, attention should be paid to rock chutes, tips, ore-bins and the shape of stopes. In addition, carefully graded tracks, straightened out wherever possible, with check rails on all sharp curves, are recommended.

Hoisting of Rock.—The largest size of skip, compatible with the power of the engine, is advocated. Ore bins of ample capacity, suited to the requirements of the level or levels of both vertical and incline shafts, are recommended, in order that, as far as possible, skipmen may be prevented from making unnecessary trips with empty skips. Shaft rails should be sufficiently heavy to allow of a maximum speed being attained during each trip.

General.—The capacity of men for doing work is an important point to bear in mind when study ing the question of hours of work underground. Attention should be given to the organisation of gangs on the lines of physique and tribal preferences for certain classes of work, such as, for instance, the preference shown by the Xosa for shovelling. Further, some form of tuition might be given to new gangs which are made up along these lines, and in this case task work or contract work would more likely prove successful.

The time taken by a native to get to work should receive consideration; the descent down thousands of feet with a load of drills on his shoulder necessitates the expenditure of much energy, and it is unlikely that under these conditions the labourer arrives fresh at his working place.

Supervision to ensure that every native gets his breakfast before leaving the compound, and that he shall have a 'break' in the middle of the shift, with possibly the issue of a light meal, are factors worthy of consideration with a view to increasing efficiency.

Every European underground is a supervisor, and a strict sense of loyalty and justice must be encouraged. In order to inculcate these essentially human factors, rigid discipline—the greatest factor in saving time must exist. Every individual must be made to feel his responsibility and should have no opportunity of shirking or shifting it elsewhere by a system which permits of his receiving orders from more than one person. Discipline in a mine will thus be more than a catchword and hours of work made productive, so far as the capacity of the worker allows.

Finally, it is recommended that in all branches of underground work, natives should be given an opportunity for contracting as well as Europeans. It is considered that some such system of payment is the greatest incentive to work, and the importance of this point has hardly been sufficiently realised in the past." Appendices to Reports on Time and Labour Saving on the Mines.—Association of Mine Managers of the Transvaal, August, 1915. (G. H. Sm.)

MISCELLANEOUS.

Cape Asbestos Industry.—"In a recently published Government report on mining in South Africa, a description of the occurrences of asbestos and of the product is given, together with an attempt to estimate the value of the blue asbestos for commercial purposes. The extent of the deposits in the Northern portion of Cape Colony is indicated, the three districts of Kuruman, Hay, and Prieska being mentioned as constituting the largest asbestos-bearing area in the world. The Cape Asbestos Company now possesses factories for milling and manufacturing the product in England, Turin, and Hamburg, whilst a sister company in Paris has been developed to control the interests of the company in France. The cheapness of working, due to native labour, is remarkable, as also the freedom from accident. The author suggests that all properties should be worked on an underground system from the start. The classification of the product based generally on the length of the fibre is discussed, it being understood that for textile purposes about 25% of the fibre must be 1 in. and over. Outside such purposes, there should be a good market, as in roofing material in which the length of the fibre is less important. The whole Cape output of blue asbestos realises at present an average of about £25 a ton landed in England. Comparative analyses of blue asbestos and white asbestos (Canadian) are given. Blue asbestos possesses great heat-resisting properties, and is said to be unaffected by moisture, ordinary acids, chemical solutions, and particularly sea-water. The production of asbestos in various countries is given, indicating a remarkable increase in the figures for Cape Colony. With the assurance of a widening market the future progress is likely to be much more rapid.—G. E. B. Frood, *India-rubber J.*, 1917, 53, 17-20.—*Journal of the Society of Chemical Industry*, Jan. 31, 1917, p. 82. (A. W.)

New Book.

The Mining World Index of Current Literature. Vol. IX. First Half Year, 1916. Published by *Mining World Co.*, Chicago.

This handy medium, 8vo volume, of about 250 pages, is divided into four parts, viz.:—

Part I.—Geology and Mineralogy.
Part II.—Ores and Mineral Products.
Part III.—Technology.
Part IV.—Miscellaneous.

It contains a list of the publications indexed, index of author's names and also a subject index.

This book should prove most useful to all who wish to keep *au courant* with modern technical literature in these departments of industry.—J.W.

Abstracts of Patent Applications.

(C.) 17.17. Andrew Frederick Crosse. An improved process for the production of a solution of chloride of lime and apparatus for use therein. 20.1.17.

This application relates to a process of manufacture of calcium hypochlorite, particularly in solution, and to a special apparatus for carrying out this process. In carrying out the process, an emulsion of milk of lime is formed by agitating water mixed with lime by means of air or other suitable gas under pressure. Chlorine gas is introduced during the agitation, forming hypochlorite of calcium. By means of the continuous displacement of the formed hypochlorite by fresh milk of lime, and by means of its automatic withdrawal, the chlorine added, is continuously reacting with fresh milk of lime, and a hypochlorite of constant strength is formed and withdrawn. The apparatus described consists of a continuous water feed; a generator for evolving chlorine by chemical reaction; and an agitating vessel consisting of an inverted cone in which agitation is carried on by means of an air-lift and displacement of solution is effected by means of a circular baffle.

Changes of Address.

Ingram, J., *to* c/o H. Wood, Esq., P.O. Box 111, Roodepoort.

Jones, Acheson, J., *l/o* Millsite; Van Ryn Deep, Ltd., P.O. Box 225, Benoni.

Rowe, C., *l/o* Cleveland; Ferreira Deep, Ltd., P.O. Box 1021, Johannesburg.

Salkinson, A., *l/o* Brakpan; P.O. Box 231, Johannesburg.

Sharpley, H., *l/o* Piggs Peak; Post Office, Barberton.

APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. MAY 1917. No. 11.

Proceedings

AT

Ordinary General Meeting, May 19, 1917.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building on Saturday, the 19th May, 1917, Prof. J. A. Wilkinson (President) in the Chair. There were also present:—

13 Members: Messrs. Jas. Gray, H. A. White, J. Chilton, C. Toombs, John Watson, Dr. W. A. Caldecott (Members of Council), N. M. Galbreath, C. J. Gray, W. H. Jane, E. A. Osterloh, J. J. R. Smythe, J. A. Taylor and T. P. Waites.

3 Associates and Students: Messrs. O. A. Gerber, J. Gibson and J. A. Woodburn.

4 Visitors and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Meeting held on the 21st April, 1917, as recorded in the April *Journal*, were confirmed.

ELECTION OF NEW MEMBERS.

Messrs. C. Toombs and Jas. Gray were elected scrutineers, and after their scrutiny of the ballot papers, the President declared the following gentlemen unanimously elected to membership:—

Rogers, Arthur William, P.O. Box 401, Pretoria. Geological Surveyor.
Thomson, Alexander Robert, Wankie Colliery, Rhodesia. Mine Manager.

Since the last meeting the following gentlemen had been admitted Associates of the Society:—

Blewett, W., c/o Messrs. Kynoch's. Ltd., Birmingham, England.
Steart, Frederick Anthony, Mines Department, Dundee, Natal. Deputy Inspector of Mines.

General Business.

VISIT TO CHANDLER'S BREWERY.

The President: A week ago, as you are aware, we had a very pleasant and a very profitable excursion to Chandlers' Brewery, at Ophirton. The malting floors which, I think, must be quite model floors for South Africa, deserve special mention, and also the fact that the industry may be described as being almost wholly South African. The barley required comprises 98% of the raw solid material, and is wholly South African, and the brewer expressed himself as being very delighted with the quality grown in this country. The only importation consists of the hops, which makes up the other 2%, hence one is not very far from the mark in calling it a truly South African industry.

There is no need for me to dilate further on this visit, except to say, that I am very glad, that it was so well attended. I have very much pleasure indeed in proposing that the thanks of the Society be tendered to the directors and staff of the brewery, who so kindly and so thoroughly undertook the work of showing us their plant on that particular afternoon. (Confirmed with acclamation).

ANNUAL GENERAL MEETING.

The Secretary: I would like to draw attention to the fact that the Twenty-first Annual General Meeting of the Society will be held on the fourth Saturday in next month, the 23rd June, at the usual time and place.

Nomination Forms for the election of the new Council and Officers have been sent out to all members, and should be returned to me not later than the 24th May, after which the Ballot Forms will be sent out in due course.

GOLD IN PEBBLES.

The Secretary: Following certain discussion on Dr. Mellor's paper on the "Conglomerates of the Witwatersrand," the following letter has been received from Mr. Alex. Selanders, the Acting Manager of the Eldorado Banket G.M. Co., Rhodesia:—

"Some time ago your Society had a discussion on the occurrence of gold in banket formation and, I think, it was maintained that though gold was associated closely with the pebbles, it was not known to be actually in the pebbles themselves. This mine was referred to in the discussion. Quite recently I split up a pebble from this mine, which showed a good deal of gold between it and a schist matrix. I am sending you a portion of the pebble showing gold actually in the pebble itself. This is the only instance I have heard of in this mine, and will be of interest to your Society."

The pebble was handed round for the inpection of members present.

SUGAR FOR DUST FILTERS.

Mr. James Gray *(Vice-President):* I would like to point out, in connection with the discussion on this subject at the last meeting, that it was stated in the *Journal* that I said the sugar used should pass a 20 mesh. This is slightly wrong, and should read as follows: "it should pass a 10 mesh, and remain on a 20, in other words [− 10 + 20].

THE NATAL COALFIELDS—PHASES IN DEVELOPMENT.

By Wm. Taylor Heslop, (St. George's Colliery).

Nearly fifty years ago Peter Smith, the father of Dundee, commenced to dig coal from an outcrop in the bed of the spruit, near to the present day town of Dundee. With rail-head somewhere to the south of Maritzburg, the demand for coal was very limited. The method of working was simple in the extreme. The "colliery-owner" made a charge of ten shillings per ox wagon load, and allowed the purchaser to dig the coal and help himself!

During the year 1888 the railway was completed to Dundee, the railway truck displaced the ox-wagon, and the Dundee Coal Co. commenced active operations at Dundee. In the year 1889 the coal output made up from collieries at Sundays Power, Wessels Nek, and Dundee, reached a total of 25,609 tons. Since then there has been, not a rapid, but a steady progress year by year, with hardly any set-backs except those due to the incidence of war.

During those many years of development there have been phases and landmarks of history of sufficient interest to be placed on record.

In 1881 the Natal Colonial Government employed Mr. Frederick North to report on the coal resources of the Colony of Natal. North traversed from end to end a country without railways, without roads, and with only rudimentary topographical maps. He compiled a mass of sections, and analyses of coal as it occurred at the outcrops, that are still of great value for reference. He made maps, which still give reliable information as to outcrops, and only erred by including a few areas, as probably coal bearing, which subsequent boring, or geological investigation, have proved to be barren. His investigations furnished justification to the Government of the day to push northward from Maritzburg with railway development. By the time the railway had reached Ladysmith the opening of the Rand Goldfields gave courage to the more timid of the advocates of railway development. The first proposals were to lease the present route of the main line of railway at Elandslaagte, follow the old transport road, pass through the Biggarsberg Range at One Tree Hill, and on by Calabashlaagte to Newcastle. This would have left the whole of the Dundee District miles away from the railway. More recent investigations made by Mr. F. A. Steart, Inspector of Mines, have proved, that this route would have left the coal-bearing areas near Wessels Nek, have traversed an older geological formation, viz., Ecca Shales, for about fifty miles, and only again touched the coal measures when within a mile or two of Newcastle. Fortunately at that time Dundee had some zealous champions, amongst whom the late Sir George Sutton and Mr. C. G. Willson were conspicuous, whose advocacy secured an alteration of the route, by way of Glencoe Junction and Hatting Spruit.

From Glencoe Junction the Dundee Coal Co. constructed a branch railway to Dundee, and very soon the coal trade became an active factor in the public economy of the Colony of Natal. Railway connection to the coalfields was of vital importance, not only to the collieries, but also to the railways, and the colony. Before that time all locomotive coal was imported, and in 1885-6 the cost of running the railway was six shillings per train mile and the actual earnings were slightly less than that amount. The railway was being run at an actual loss. By the end of 1888 the running costs had been reduced to four shillings per train mile, and the earnings had jumped up to seven shillings and four pence. From the verge of insolvency the railway had become a highly profitable institution, and the credit of the Colony was saved.

The Dangers of Firedamp.—For some years all the coal was worked from outcrop adits, and shallow pits, in a primitive way, and with primitive appliances. During 1897 the Natal Navigation Collieries put down a pit to a depth of 200 feet and encountered considerable quantities of firedamp on reaching the coal. Firedamp became an active menace to safety in coal mining, and the collieries were hardly prepared for it. Mining regulations also were crude and ineffective, and the Government appointed a Commission to compile new regulations. With deeper sinkings, the question of fire-damp assumed more serious proportions. In 1899 an explosion took place at St. George's Colliery, resulting in the death of one European and three natives, and injuries to five others. About this time smaller explosions took place at Elandslaagte, Natal Navigation, Campbell Colliery and South African Colliery. In 1901 one European and thirty natives were killed by an explosion at the Campbell Colliery.

In 1906 an explosion took place at Elandslaagte Colliery, resulting in the death of eighteen natives and Indians. The culminating explosion of the coal field took place at Glencoe Colliery in 1908 when twelve Europeans and sixty-three natives lost their lives. In this explosion two new features for this coalfield were introduced; firstly, the mine took fire, and a series of some six separate explosions took place, and secondly, the final explosion was partly due to firedamp and partly to coal dust.

A few months later, an explosion similar in almost every respect, except that there was no loss of life, took place at the Cambrian Colliery. Such a series of disasters naturally had a salutary effect on the conduct of mining operations. More care was exercised in supervision, both by Managers and Inspectors, and in the actual work of mining, experience was gained by both white and black employees.

The methods and customs of the outcrop collieries of the Transvaal and Natal had to be gradually discarded or revised. Ventilating fans of Capel, Schiele or Waddle types were installed at nearly every colliery. The use of any but "permitted" safety explosives was stopped, and shot firing by electricity became universal. At a later stage, when the dangers of coal dust became manifest "stone dusting" not only of main roads, but of completed workings near the faces was adopted. The stone dust generally employed consists of sifted ashes, and does not contain sufficient silica to be a source of danger to health.

The Deeper Sinkings and the Dolerite.—As the sinking of deeper shafts were proceeded with, it was found that large horizontal sheets of intrusive dolerite had to be passed through, and this is a characteristic feature of the coalfield. The coal in proximity, or even at considerable distance to the dolerite was naturally coked by the tremendous heat, and converted into anthracite or semi-anthracite, according to whether it was near, or further away from the originally molten rock. These lateral intrusions of molten igneous rock extended in many cases for several square miles, and in thickness up to 400 ft. As the sheets of dolerite cooled, they contracted to some extent, forming vertical cleavage planes, producing huge polygonal columns, sometimes hexagonal, but often irregular. Near the adjacent sedimentary rock, with which it was in contact, cooling was more rapid, and in consequence there was a kind of case-hardening which left the dolerite sheet always hardest at the outside and softer and more coarsely granulated in the centre. The basaltic columns of the Giant's Causeway, in the North of Ireland, and at Staffa and Iona in Scotland, are familiar examples of the columnar structure above described. In the upper reaches of most of the mountains of the high veldt, the same formation can be observed.

In sinking through such rock the miner found it exceedingly hard to drill and to blast, and heavy charges of explosive were required, and in such hard rock progress was slow and difficult. The extra hardness of the upper portion of the sheet gave a sense of security, but the vertical columns, although hard, were only loosely attached to each other. Moreover, they frequently were not truly vertical, and as the shaft was deepened, on one side or the other, the foundations of one of the huge columns were gradually undermined, and there was grave danger that even in a well timbered shaft, an undermined column would slip down, drag the timber with it, and thus be a source of danger to the workers.

At the Ocean Colliery, to the south of Elandslaagte, and at the original South African Colliery, shafts were sunk through the dolerite, and abandoned after completion. At Glencoe and Cambrian Colliery, thick sheets of dolerite, in the latter case 280 ft., were successfully sunk through. In addition to the columnar structure already mentioned, the dolerite has a distinct, although less clearly defined, slatey cleavage which is at right angles to the column. This characteristic is of considerable value when bore-hole cores have to be examined with a view to determination whether the dolerite exists in the form of a sheet or otherwise. At the junction with the country rock there is frequently a certain amount of "absorption" matter, *i.e.*, sedimentary rock has been fused and absorbed into the igneous flow. The variations of texture and colour at points as far as 4 ft. from the contact are evidence of this. Against the contact, sandstones are frequently fused to quartzite, and shales are robbed of their carbonaceous components, and have become white in colour, instead of blue or black.

The Action of Dolerite on Coal.—The difficulties incidental to the piercing of the dolerite sheets in order to reach the deeper coal seams, serious though they may be, are trifling compared to the geological effects of the dolerite on the Natal coalfields. There are comparatively few places in the coalfield, where a deep drill would not intersect one or more horizontal sheets of dolerite. The extent and continuity of these intrusions is without parallel in any coalfield of the world. In other fields the igneous intrusions may be of a larger scale, but the extent of lateral travel, in the shape of sheets, is very much less. A vertical intrusion will, by the heat emitted at the time of extrusion, deleteriously affect the coal for some yards on either side, but the horizontal sheets frequently affect the coal over areas many square miles in extent. Between Hatting Spruit and Dannhauser, and extending east and west, there is an area of over 50 square miles in extent affected in this manner. Several years ago the writer estimated, that about three-fourths of the Natal coal areas were affected by igneous action. Subsequent exploration and investigation indicates that 90% would have been a much nearer estimate, and that of the total coal areas of Natal, not ten per cent. can be considered of sufficiently good quality for present day market requirements.

The speculator, who has the misfortune to lay out his money, without making sure that he is exploiting some of that ten per cent. of good coal, instead of some of the ninety per cent. of inferior mineral, is likely, therefore, to pay dearly for his experience. Thanks to those, who have paid thus dearly, Natal coal is not a popular field for the capitalist.

The stranger to Natal, whether mining engineer or layman as far as coal is concerned, frequently asks how it happens that in Wales and in Pennsylvania anthracites and semi-anthracites can be used to such advantage, whereas in Natal it should be discarded as useless. In Wales, anthracite is mined to a considerable extent, and used for special purposes, such as malting, and in suction gas producers. The semi-anthracite, or steam coal, containing 12% to 15% of volatile matter, is used for naval purposes, and is considered the best steam coal in the world. The Pennsylvania anthracite is used almost exclusively in New York for domestic purposes, and is also used extensively for steam-producing purposes. Then why should a similar class of coal be refused a market in Natal?

The best answer to this question is to try the experiment of burning Natal anthracite. If we burn a piece of bituminous coal we notice that tarry matter bubbles from it, and that the whole lump swells up, and leaves a porous spongy cinder. The Natal anthracite on the contrary does not swell up and become spongy, but decrepitates violently into splinters, which burn from the outside, until surrounded by a non-conducting jacket of ash, which shuts off the further access of oxygen. This ash in reality contains a nucleus of unburnt coal, and that nucleus represents lost fuel and reduction of efficiency. The envelope of ash indicates retarded combustion, *i.e.*, a slow burning coal. The Welsh coal with only 1% to 3% of ash, cannot furnish sufficient material wherewith to manufacture a combustion retarding envelope, and moreover has not the same violence in decrepitation. The American coal has more ash than the Welsh, but less than Natal, and experience has compelled the use of shaking fire bars to throw off the superfluous ash, and thus accelerate combustion. Some day, not so many years hence, we shall be compelled to adopt similar expedients. Meanwhile there are large areas of coal, more or less affected, for which there is no present demand.

although bye-products and suction gas developments may furnish an outlet.

The range of action of the dolerite on the coal depends on the thickness of the former, and on the thickness of intervening strata. Generally the effect will be noticed for a distance equal to 66% to 75% of the thickness of the sheet. In an actual test by the writer, coal was affected for a distance of 17 ft. from igneous intrusions 22 ft. thick.

Winning the Coal.—In the early days of the industry all the coal was cut by hand picks, and small pillars were left to support the roof, with no thought of future extraction. Before long the irregularity and unreliability of native labour compelled mine managers to turn their attention to mechanical methods of coal-cutting. To Mr. David Harris of Elandslaagte belongs the honour of being the first to introduce mechanical coal cutters, not only into Natal, but into Africa. In 1899 he installed an experimental Jeffry electric driven coal cutter. Its success led to a complete installation of coal-cutters and electric locomotives a little later. At a still later period he superseded the Jeffry machine with the stronger and more adaptable Sullivan chain machine.

In 1902 the Dundee Coal Co. installed a large Jeffry coal-cutting plant, and Jeffry electric locomotives, before which time their plant and methods were primitive in the extreme.

Scarcity of native labour compelled other collieries to follow suit. Where fire-damp was prevalent, electricity as a motive power was inadmissable, and the collieries were obliged to instal compressed air. With compressed air, there was more latitude in the choice of coal-cutting machines. St. George's Colliery adopted the American "Puncher" of Sullivan make, and, to use an Americanism, "fool-proof" in character. Natal Navigation, with characteristic Scotch caution adhered to the Jeffry type already proved by Harris at Elandlaagte. At the Durban Navigation, Mr. T. G. Colquhoun introduced the newer Siskol percussive machine, and his example was followed by the Glencoe and Cambrian Collieries. Gradually every colliery installed some form or other of mechanical coal cutters.

At most of the collieries mining is on the "bord and pillar" system, the "bords" being from 5 yards to 6 yards wide, the size of pillars being dependent on depth, up to 30 yards square. At some of the shallow mines with thin seams the Welsh single or double shell method has been adopted to a considerable extent, and a good roof tempted with stall widths up to 42 ft. The long-wall method has not been adopted to any extent, although at some mines the natural conditions are very much in its favour.

For the haulage from the tramming stations to the shaft the endless rope system is almost everywhere in use. Where conditions are normal the ordinary swan neck jockey is generally used. At several collieries a jockey [illegible] of crucible steel but on the same principle as the swan-neck jockey is found to have many advantages in point of both efficiency and maintainence costs. Its use upsets the principle held by many engineers, that the material of the jockey should not be as hard as the material of the rope. The justification is, that a jockey, that grips, causes less wear to the rope than a worn jockey of softer material, that allows the rope to slip through it. The crucible steel jockey head swivels on a mild steel shank.

In many mines branch haulage roads are operated from separate ropes driven from the main haulage by a keyed C type wheel operating a friction clutch. In others the one rope is carried round the branch and back to the main system, in which case a derailment on the branch entails stopping the main haulage. Formerly electric locomotives were employed to a considerable extent at Dundee and Elandslaagte, using continuous current at about 250 volts from bare overhead conductors, but maintainance was found to be too expensive.

Pillar Extraction.—In the early days of the field, the pillars of coal left to support the roof were as small as possible; managers for the most part thought the coal field inexhaustible, and that it was quite unnecessary to think of extracting pillars, whilst coal owners, generally speaking, were not aware, that it was possible to extract pillars. In one case directors were so impatient for output, that pillars were reduced below safety limits, and the colliery nearly sacrificed entirely, in the effort to meet those impatient demands. With deeper workings, it became necessary to leave larger pillars to support the heavier roof, and it was incumbent upon engineers to consider and adopt methods of working, which would permit of the extraction of all the coal, instead of wasting 30% to 50%. Where only one seam of coal was concerned, this involved no special difficulty, provided that the ultimate extractions of pillars was kept in view during the period of preliminary development, and the temptation to obtain cheap immediate output resisted. Where, as at many collieries, there are two workable seams in close proximity to each other, the difficulties of pillar extraction, such as they are, have increased enormously. All pillar extraction, it may be noted, involves the breaking and subsidence of the superincumbent rocks. In the coal mesures these rocks break much more readily than the quartzites of the Witwatersrand, and also can be depended on to bend to some extent before they break.

If the lower seam is extracted first, it is almost impossible to take out any reasonable proportion of the upper seam, without running grave risks. If the upper seam is extracted first, when the lower seam is tackled, only from 2 ft. to 6 ft. of sandstone protects the mines from the whole mass of broken rock overlying it. Heavy timbering is, therefore, necessary to protect the roads in the lower seam, and even then the roof gradually bends down or collapses under the strain. In consequence it is expedient to do as much as possible of the development on the retreating system, delaying the blocking out of pillars as much as possible. Alternatively, the writer has found that a system of blocking out both seams into pillars, exactly overlying each other, then taking out pillar by pillar, first the top seam, then the lower one, saves much of the cost of road maintainence, and offers many other advantages. The total extraction of two seams lying so close to each other, has not been generally attempted, and has involved a good deal of experimental work, as well as the consideration of the effects of big earth movements, and their action both on roof and on coal.

The primary object of working both seams out entirely, is of course the prolongation of the colliery's life, by preventing the waste of coal. From a company's point of view, that is only justified if the profits gained during the added period of life, more than compensate for any extra working costs. Such a policy can only be possible when both manager and directors are prepared to face the future, as well as the present.

But from the point of view of the public interest, the question whether any colliery should be allowed to waste national assets, which can never be replaced, is one of paramount importance. South Africa is by no means so rich in coal as was formerly supposed, and even if the individual shirks his duty to future generations, the national spirit will, sooner or later, recognise national responsibility towards posterity. Coal is being wasted to-day in South Africa in a manner, that no British royalty owner would ever for a moment permit in one of his mining leases. The British royalty owner has only his family to consider, South Africa its responsibility to the future of the nation. To prevent such waste by prohibitive legislation is by no means an easy problem.

Questions of payability of seams, and more particularly, of what constitutes waste, are by no means easy. A special tax on wasted coal, or preferably a tax on output wherever workable coal is being wasted, would be somewhat simpler, and more practicable. The difficulties would be great, but such as they are, they have been in practice overcome by British royalty owners. The extraction of pillars from both seams, solves another problem which, during the last few years, has loomed large in Natal coal mining, namely, the problem of goaf fires.

Goaf Fires.—During the last half dozen years the fears of fire-damp have been largely superseded by the fear of goaf fires. In 1908 the first goaf fire in Natal commenced at St. George's Colliery, in an area where the top seam had been sacrificed, and pillars were extracted, the top seam coal fell and was crushed. After a time carbonic acid gas was observed at the goaf edge. This was followed by the benzene odour characteristic of the distillation of coal at low temperature, by indications of heat, and emission of explosive hydrocarbon gases. The area was promptly dammed off, and any more serious consequences averted. The sequence of fires at that mine, during the next few years, was limited to an area where the coal was semi-bituminous, and indicated that coal, which has been subjected in any degree to igneous action, is more liable to spontaneous combustion than purely bituminous coal. But the fact remained that it was the coal left as waste in the goaf that burned, and if all the coal were taken out there would be no fuel to feed a fire. In extensive areas where both seams have been extracted has been no trouble from spontaneous combustion. Following this, fires occurred at Glencoe Colliery, Cambrian Colliery, and Durban Navigation and Hatting Spruit Collieries. At last, at the Natal Navigation Colliery a fire, in process of being built off, ignited the explosive gases, which it had generated, and a serious explosion occurred, followed by a second explosion the next day. In consequence, the greater portion of the mine was walled off, and abandoned for about a year. It was only recovered after putting down an elaborate system of bore-holes, and sand filling the goaf margin from the bore-holes. In all these fires, coal had been sacrificed in the goaf, and by spontaneous combustion, exacted Nature's penalty against waste.

In dealing with a goaf fire in a fiery mine, there are three great dangers that always have to be faced. The first—that the generation of volatile hydrocarbon may result in accumulation of explosive mixtures, and when the fire ultimately bursts into flame, either that accumulation, or some accumulation of fire-damp may become ignited. As the generation of hydrocarbons is difficult to check, the only safe course is to deal with the other explosive element, oxygen, and check the admission of fresh air. In nearly all cases the generation of carbonic acid gas will, by using up the oxygen, serve as a sufficient safeguard, but under certain conditions there may be exceptional facilities for a gravity separation of the heavier carbonic acid gas from the lighter hydrocarbons, and then, if oxygen is available to the latter, the danger of explosion is very serious. The second danger is carbon monoxide poisoning. Fortunately, the accompanying benzene compounds give a warning odour, and only one fatality to a native, and another to a dog, have come to the writer's notice. Nevertheless, he has vivid recollections of the effects of loss of muscular power in the knees, of accelerated heart action, and of the subsequent severe headaches and sickness. The inhalation of oxygen has proved very beneficial in such cases. The third danger is that the fire may get out of hand and the whole mine be lost, if the trouble is not tackled promptly and vigorously.

Preparation of Coal for Market.—In the early days of the Natal coal trade appliances for screening and cleaning the coal were of the most primitive description. Of this, the plant at Dundee No. 4 Pit was an excellent illustration. The mine trucks were tipped over a fixed bar screen. A couple of coolies at the base of the screen, and another in the railway truck, picked out occasional lumps of shale. The smalls passing through the bars fell into another mine tub, which, when full, was transferred to a small cage, and raised to an upper level by a small drum attached to the winding engine. There it was again tipped over a wire screen, suspended by chains, and oscillated by a coolie standing on each side. The nuts passed into a railway truck, and the dross coal was again raised in the cage to the upper level, and from there transferred to the dump.

With a seam of coal very free from shale, this method was fairly effective as at Dundee, but other collieries less favoured by Nature, had serious trouble through sending away badly cleaned coal, and in 1896-7 Natal coal earned a bad reputation for this reason. In 1898 T. G. Colquhoun put up the first modern jigging screens and picking tables at the Natal Navigation Colliery, and this was followed immediately with a similar plant, by the St. George's Colliery. After that it became a *sine qua non* for every new colliery to put up a modern screening plant, with elaborate provision for both screening coal and sorting out shale. Although these screening plants provided for the effective cleaning of the large coal, they were of no practical use for the separation of shale from nuts and peas. Nuts and peas, moreover, were a drug in the market, and thousands of tons had to be thrown on the dump. The collieries were in consequence compelled to turn their attention to the question of coal washing, in order to find a better market for their small coal. During the years 1904-7 the erection of washing plants became the order of the day. Washers of the pulsating jig or Baash type were installed at Navigation, Glencoe, South African, Cambrian, and Newcastle Collieries. Elandslaagte installed a Shepherd Washer and St. George's a Baum washer. Later, two other collieries installed Primus Washers. Most of these plants involved an expenditure of £6,000 to £7,000. As a result, markets were found, first for nuts, then for peas, and lastly for dross also. Some collieries, which formerly marketed only 60% to 65% of the coal produced, are now able to dispose of 95%. Consumers, such as the Durban and Maritzburg Corporations, which formerly used nothing but round coal, now consume nothing but fine dross, which the collieries still persist in selling at much below its real value as a fuel.

Irregularity of Markets.—One of the difficulties which tend to increase the cost of production, is the irregularity of output on account of the nature of the shipping trade. The demand for coal is always fluctuating, according to the demand for bunker coal. Consequently, the collieries have always to endeavour to maintain a margin of capacity over and above actual output. If the shipping trade is to be nurtured, it is necessary that boats should be able to rely on getting coal without delay, whenever they come into port. That is met to some extent by stocks in truck at the port, and to some extent by the 10,000 ton bin at the Bluff; but even these provisions are inadequate. The margin of railway capacity, whether in trucks or locomotives, is nearly always inadequate, and rarely indeed can collieries depend on getting a full truck supply for six consecutive days. At a modest estimate, this irregularity costs Natal Collieries £100,000 per annum. To minimise the loss and inconvenience most of the larger collieries have during recent years erected storage bins of from 600 to 2,000 tons capacity, and the advantage has been of very material value to them.

In the foregoing remarks the writer has treated the matter from an historical standpoint, which has necessitated a very general description of the coalfield and collieries of Natal.

The President: We are fortunate in having with us this evening Mr. C. J. Gray, who was formerly Commissioner of Mines in Natal. I do not think any further introduction is necessary, and I beg to call upon him to propose the vote of thanks to the author for this most interesting paper.

Mr. C. J. Gray *(Member):* I have much pleasure in proposing, that a hearty vote of thanks be accorded to Mr. Heslop for his excellent and most interesting paper. In this paper he has given very little indication, of the part, which he personally has taken in the development of the coal industry of which he has given the account. I have known him from before the South African War. All through that period he has been actively engaged in making the coal industry of Natal a more scientific and a more enterprising one. He has taken part in all the improvements, that have been recorded in his paper; he has seen the industry grow from the very primitive one, which he has just described, to its present, of a highly scientific character. The method of mining has developed from the small pillar system, the pillars in which were never extracted, to a regular system of extracting large pillars, and, while he laid stress on the coal, which is wasted, he might have drawn attention to the fact that the present waste is small in comparison with what it used to be under the old system. I do not think it is necessary to enter into detail with regard to the paper at the present time. I hope that the vote of thanks to Mr. Heslop will receive the approval of this meeting.

The President: There was one sentence in the paper which struck me very forcibly —that is, where the author refers to the fact that the Coal Field of South Africa is not a very old one. I had occasion some time ago to make an attempt to find out what was the proportion of coal in this country to the known amounts of the world, and I do not think, as yet, it is fully realized—taking Mr. Kotze's estimate, which is an approximate one, into consideration—that the proportion of coal in this country to that which is known to exist in the world is four-fifths of one per cent. The man in the street, of course, looks upon South Africa as being a practically illimitable coal field, but, if he were told South Africa possessed one four-fifths of one per cent. of the coal supply, he would look upon the coal we have here in a very different fashion, and I quite agree with the author, when he says that even coal owners must not be allowed to waste such a valuable national asset as this is. More particularly does that come home to us if we attempt to realize what a very small proportion of the world's supply of coal there is in this country.

I have nothing more to say on this paper, as I am not a coal miner, and, although I take a deep interest in the subject, I am not able to present anything of any value to discussion on such a paper as this, but I hope, that some of our mining members will come forward. They probably have been engaged at some time or other, in the extraction of coal previous to their work in metalliferous mines. If so, I hope they will give the members of this Society—who are, by-the-way, more conspicuous by their absence than their presence at these meetings—the benefit of their experiences.

I have very much pleasure in putting this vote of thanks.

NEUTRALIZATION EFFECT OF ASH ON ACID-SAND IN STOPE FILLING.

By Chris. Toombs *(Member of Council).*

(Printed in Journal, November, 1916.)

REPLY TO DISCUSSION.

Mr. C. Toombs *(Member of Council):* I have to thank Mr. F. W. Watson for his contribution on my paper. Probably he is correct in saying, that we are favoured by the quality of our ash, the dump in use being largely from a very low grade coal. His experiments with the ferrous sulphate solution are hardly comparable with what takes place in stope filling, aeration conditions being unfavourable, and time of contact comparatively short. However, the scheme has been very successful, and a distinct economy has been effected in the saving of lime required for eliminating free sulphuric acid and ferric sulphate.

FLOTATION CONCENTRATION EXPERIMENTS ON A TRANSVAAL GOLD ORE.

By F. Wartenweiler (Member of Council).

(Printed in Journal, November, 1916.)

REPLY TO DISCUSSION.

Mr. F. Wartenweiler *(Member of Council)*: I had hoped that Mr. Galbreath would have supplemented my laboratory notes with some of his practical experience on Transvaal antimony ore flotation. Perhaps he will favour us with a paper some day. With regard to his queries about the use of acid, results showed no improvement over the neutral or alkaline circuit with the particular ore experimented with, either in percentage recovered by flotation, increase in grade of concentrate or saving of time of agitation.

As the object was to determine or obtain a line on floating the sulphides of this ore under the practical conditions best suitable to the locality and existing plant, the use of an acid circuit was gladly discontinued when it was discovered that an alkaline or neutral circuit gave equally good results. I do not think it will serve any useful purpose to give detail results on flotation in the acid circuit as suggested by Mr. Adam. I agree with him, that a great deal of analytical work might be done to arrive at closeness of the association of the gold with the "refractory" mineral to enable one to control the degree of concentration more intelligently. Generally speaking, the experience on the ore in question has been, that wherever the gold is associated with sulphides it is comparatively refractory to cyanide treatment unless when prepared by the roasting of the sulphides.

Mr. White's remark on flotation tests on Rand banket ore are pertinent. Considerable investigation along academic lines has been carried on at the Rand Mines Laboratory on such ore, and it is hoped that the findings will supply the subject matter of a short paper in the future.

NOTES ON TREATMENT OF PILGRIMS REST ORE.

By Robert Lindsay (Member).

(Printed in Journal, April, 1917.)

DISCUSSION.

Mr. F. Wartenweiler *(Member of Council)*: To me, the striking feature of Mr. Lindsay's paper is the wide opening of the doors and records of the principal reduction works of the district to all who take an interest therein. The wealth of detail and careful description should be particularly valuable to the small operator milling similar ore, and for these and their publication they will owe a debt to the author and the management.

Commenting on the subject matter, I have always been impressed by the means of control afforded by having separate crushers, crusher bins, and divided mill bins for various ore bodies, making possible the taking of daily screen samples which reflect the value and mineral composition of the ore. This has been successful practice at the Central Mill, Transvaal Gold Mining Estates, for a number of years.

In the cyanide treatment of the sand, by-passing the extractor boxes, of gold-bearing solutions is carried on to an unusual degree. The precipitation of the copper-gold bearing solutions is extremely interesting, and illustrates what can be done by careful study and manipulation. In this section of the paper the author might tell us something more of the physical condition of the gold and copper precipitate in the different compartments of the extractor box. The description of the well established precipitate refining methods are especially valuable to a metallurgist having to deal with such a base product.

The metallurgical practice of two of the plants described, Central and Vaalhoek, shows considerable variance from practice on copper free ore, and its smooth working and unusual features reflect credit on the author and also on Mr. A. Scrymgeour, an earlier investigator.

The President: (After calling for discussion on the other papers on the Agenda): Well, if there is no discussion on these papers, gentlemen, I have only one alternative—that is, to declare the meeting adjourned but, before doing so, I would like to say that I hope that every member will do his best to create a little more interest in these meetings, than has certainly been shown since the beginning of this year. On the one hand, the papers have been quite up to standard, but the attendances have been very small, statements no one can challenge. There is no other reason for the decrease in the attendance of members at the monthly meetings, than, of course, the all-absorbing topics of the moment; probably these serve to keep some people away but, on the other hand, they are really very excellent excuses, if excuses be required. It is our Annual Meeting next month, when we hope to see a large increase in the attendance of members to hear the two papers which will be then read, and the Annual Report of the Council.

The meeting then terminated.

ASSAYERS' CERTIFICATES.

The attention of Assayers in the Union is drawn to the fact that the Mines and Works Regulations, framed under the Mines and Works Act (No. 12 of 1911), have been considerably amended and added to by the issue of Government Notice, No. 728, dated the 30th May, 1917, which makes it essential for Assayers to be in possession of Certificates of Competency.

For the information of Assayers, the full context of the Regulations dealing with their Certificates is published hereunder.

PART IV.—CERTIFICATES REGULATIONS.

CHAPTER XXVII.

A. GENERAL.

Regulation 284.—Persons wishing to obtain Certificates of Competency as provided for in this Chapter shall make application therefor to such Commissions of Examiners as shall be appointed from time to time. Such Certificates shall be granted or withheld by the Government Mining Engineer in accordance with the recommendations of such Commissions who may in particular recommend to the Government Mining Engineer that certain limitations or qualifications be endorsed upon the Certificate.

The Government Mining Engineer may refer any recommendation of any Commissions back to the Commission for such further report as he may require, and in case he dissents from the recommendation of the Commission, he shall refer the matter to the Minister, whose decision shall be final.

Regulation 286.—Each such Commission shall be selected, appointed, and discharged by the Government Mining Engineer, and shall furnish regular reports of its proceedings to him.

Regulation 287.—Examinations shall be held by the said Commissions at such times and places as may be determined upon by the Government Mining Engineer.

Regulation 288.—Notice of every examination shall be communicated in writing to every person who has been duly accepted as a candidate.

Regulation 289.—Rules for the conduct of the examinations by every such Commission shall be framed by the Government Mining Engineer, who shall have power to alter such rules as occasion may require.

Regulation 290.—A quorum of any such Commission shall consist of the chairman and two members, and should any difference of opinion arise in any matter connected with the examination of a candidate, it shall be decided by a majority of votes of the examiners. If the votes be equal the chairman shall have the casting vote.

Regulation 292.—The following persons shall be qualified to receive a Certificate of Competency from the Government Mining Engineer, without examination, as provided hereinafter, upon the recommendation of any Commission of Examiners: provided that the Commission may examine every such person in such portions of the laws of the Union as may be laid down by the Government Mining Engineer :—

Section (5).—An assayer who satisfies the Commission of Examiners for Assayers' Certificates that he possesses diplomas or certificates indicating, in the opinion of the Commission, a satisfactory knowledge and training in theoretical and practical analytical chemistry, or that he has been employed as chief assayer on any mine employing more than 200 persons underground for a period of at least two years.

Regulation 293.—Every application for a Certificate of Competency shall, when handed or sent in, bear revenue stamps for the following values :—

Section (5).—For an Assayer's Certificate, £3.

Regulation 295.—On proof being furnished to the satisfaction of the Government Mining Engineer that any of the certificates mentioned in Regulation 293 have been lost, and that notice of the loss thereof has been advertised three times in a local newspaper, a new certificate shall be issued to the holder on payment of a fee of one pound. . . . . . Such new certificate shall bear the word "Duplicate," and the prescribed fees shall be paid in revenue stamps.

E.—ASSAYERS' CERTIFICATE.

Regulation 304, Section (1). The Commission of Examiners for an Assayer's Certificate of Competency shall be constituted as follows :—

The Government Mining Chemist or a Government Analyst, who shall be Chairman, an Analytical Chemist, and a Metallurgist, of whom at least one shall be engaged in academic work, and two Mine Assayers, of whom one shall be actually engaged in assay work on a mine, and who shall, within three months of the coming into force of this regulation be holders of Assayers' Certificates.

Section (2).—Every candidate for examination shall forward with his letter of application a statement as to his age and education, and shall satisfy the Commission as to his experience, qualifications, ability, sobriety, and general good conduct.

Section (3).—He shall further satisfy the Commission that he possesses a sufficient knowledge of theoretical and practical analytical and general chemistry and assaying, and that he has had at least three years' practical experience in an assay or analytical laboratory.

Chapter XXVIII.

Suspension and Cancellation of Certificates.

Regulation 325.—If at any time the holder of an .. ..Assayer's........ .. .. Certificate issued in accordance with Part IV. of these Regulations or any subsequent amendments thereof or heretofore issued under any law in force in any Province of the Union, shall be guilty of gross negligence or misconduct or non-compliance with these Regulations, the Government Mining Engineer may, after enquiry, suspend or cancel such Certificate, or may, if he thinks fit, submit the matter for enquiry or report to the respective Commissions of Examiners appointed under the said Regulations, and may, on the recommendation of such Commission, suspend or cancel such Certificate. In the event of cancellation or suspension of such certificate, the holder thereof shall have the right of appeal through the Government Mining Engineer to the Minister, who shall, if the matter has not been reported on by the Commission of Examiners, submit it for enquiry and report of such person or persons as he may determine. All suspended or cancelled certificates shall be returned by the holders to the Government Mining Engineer within two (2) weeks of the date of suspension or cancellation.

Regulation 328.—Any person wishing to appeal under any Regulation contained in this Chapter shall proceed with his appeal within fourteen days after receiving notice that his certificate has been suspended or cancelled by filing with the Government Mining Engineer or with the Inspector of Mines for the District concerned a written statement setting out the grounds upon which the appeal is based.

A new section has been added to Regulation No. 59 dealing with the sampling of air, providing that the chemical determinations of samples "shall be conducted by or under the direct supervision of a Certificated Assayer."

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

New Lead Corroding Process. "The pig lead is weighed as required for corrosion; then run over a travelling crane to the melting furnace. This furnace has a capacity of five tons, and is heated by gas. From the furnace the molten metal is poured through a patent wire making machine, from which the lead emerges in the form of wire, granulation being avoided by keeping the wires at a red heat. The wire produced in this form retains its porous condition even under weight in the corroding vats. From this machine the lead in wire form is conveyed by travelling belt to boxes, which in turn are trucked to the incline hoist, from which they are automatically dumped into the corroding vats over planks which distribute the load and prevent its consolidation at any one point. This process is repeated from time to time as corrosion progresses.

Corrosion is effected by a weak solution of acetic acid. The corrosion vats are set on an incline, one below the other, so that the solution is siphoned from one vat to the other and kept in constant circulation, the content of the bottom vat being re-pumped back to the top of the series.

These vats are 7 ft. 6 in. in diameter, and hold a ton and a half each of lead and solution. They are made of California redwood, which does not stain the solution. The vats are fitted with false bottoms. The bottom vats are covered to ensure cleanliness and avoid evaporation of the acid. The bottom vat is 10 ft. by 6 ft. and the solution is retained here till it becomes sufficiently dense as shown by test hydrometer readings. The solution is then pumped to the precipitation vat where it is treated with carbon dioxide produced from lime rock and coke, the gas being injected by a blower pump. The gas is purified before use by being passed through a scrubber and water spray filter, which free it from tar, etc.

From the bottom of the precipitation vat the precipitate is drawn off into the washing vats, of which there are three. The acetic acid is recovered and used over and over again. From the washing vats the precipitate is pumped to the filter press, which has a capacity of five tons for each eight hours. The frames and plates are made of acid resisting yellow pine.

From the filter press the white lead is taken, in the form of cakes, and loaded into boxes in which it is conveyed to the drying room. After drying it is disintegrated by passing through wooden rolls, and placed in barrels.

The process is remarkable for its efficiency and the exceptionally high quality of the white lead produced by it."—*Mining and Engineering Record*, Oct., 1916, p. 101. (H. A. W.)

Technological-Chemical Research on Superphosphates.—"Many samples of superphosphates were examined by the author chemically and with the petrographic microscope, and experiments were made on the conditions of equilibrium of the system, lime, phosphoric acid, and water at 75° C. and at 100° C., and on the influence of various factors on the physical properties of superphosphate. Contrary to the view generally accepted, the calcium sulphate present in superphosphate prepared from mineral phosphates usually exists mainly or entirely as anhydrite; only in rare instances is it present chiefly or solely as the dihydrate. In bone superphosphate, on the other hand, usually prepared with a restricted quantity of sulphuric acid, the dihydrate is present more frequently. Mono- and di-calcium phosphates occur usually only in the hydrated form, but the anhydrous salts are also sometimes present. The physical properties of superphosphate depend chiefly on the amount of the liquid phase which is always present. For analytical purposes the liquid phase is defined as the sum of the free water and the free phosphoric acid. To determine these the superphosphate is extracted with cold 95% alcohol, and the residue is washed with a little ether, dried for 1 hour at 80° C., and weighed; the loss of weight corresponds to the free water plus free phosphoric acid. In the alcoholic solution, after dilution with water, the phosphoric acid is determined either volumetrically or gravimetrically. Results obtained with numerous commercial samples of superphosphates indicate that in general the best products in regard to dryness and friability are those in which liquid phase is less than 15%; products containing 15—18% of liquid phase are still dry and friable, those containing 18—25%

are slightly moist and readily cake. In the technical preparation of superphosphate the first stage consists in the reaction of sulphuric acid with part of the tricalcium phosphate to form calcium sulphate and phosphoric acid. In the second phase the free phosphoric acid reacts with a further quantity of the tricalcium phosphate; this reaction proceeds with appreciable velocity only above 50°—60° C., and with sufficient velocity for technical purposes only at 70°—80° C. As the temperature of reaction increases, the amounts of free water and of free phosphoric acid in the product also increase; hence attempts to improve the physical characters of superphosphate by increasing the temperature of reaction are irrational. The best results will be obtained when the reaction temperature is from 80°—100° C., and as the quantity and concentration of the sulphuric acid used in practice may be regarded as fixed, the aim should be to maintain the desired temperature by variation of other factors, such as the dissipation of heat during the process, the total mass of the system, the duration of the mixing process, and the quantity of water evaporated, *e.g.*, by ventilation of the superphosphate dens."—N. Pratolongo.—*Journal of the Society of Chemical Industry*, Oct. 31, 1916, p. 1073. (J. A. W.)

Detection of Nickel in Cobalt Salts.—"By the following method considerably smaller quantities of nickel can be detected than has been possible hitherto, and with a smaller consumption of dimethylglyoxime, even in presence of relatively large quantities of cobalt. The solution containing nickel and cobalt (about 10—15 cc.) is treated with 10% potassium cyanide solution until the precipitate which forms at first just redissolves, and the solution is heated and rotated for 5 mins. after the colour changes from greenish-brown to pale yellow. It is then diluted to 50 cc. with water at 85° C., and treated with 1 cc. of a 1% alcoholic solution of dimethylglyoxime, after which 1% silver nitrate solution is added, drop by drop, with constant stirring, until a permanent precipitate is produced. The presence of nickel is indicated by a pink colour, which appears only after some hours when the quantity of nickel is very small. It is possible to detect 0·02 mgm. of Ni in 1 hour and 0·002 mgm. in 24 hours. The effect of the silver nitrate is to precipitate the cyanide ion as silver cyanide and promote decomposition of the nickelocyanide ion, thus increasing the concentration of nickel ions, whilst the cobalticyanide ion remains practically unaffected. The increased sensitiveness of the test is probably due to increased concentration of nickel ions owing to adsorption by the precipitated silver cyanide. A similar effect is produced if silver chloride be precipitated in the mixture, but precipitation of a positive colloid, such as aluminium hydroxide, has no effect."—A. B. Middleton and H. L. Miller.—*Journal of the Society of Chemical Industry*, Oct. 16, 1916, p. 1013. (J. A. W.)

The Texture of Firebricks.—"The texture is one of the most important qualities of a firebrick, because if the chemical composition and refractoriness are satisfactory, the characters of the brick will depend on the texture, *i.e.*, on the proportions of coarse and fine grains and the spaces between them. These grains are composed of (*a*) felspathic and micaceous fluxes, (*b*) granules of clay proper, (*c*) grains of quartz, and (*d*) accidental impurities. When a clay is burned in a kiln the fluxes begin to melt at about 900° C. and then attack the surfaces of the clay and quartz grains. At a still higher temperature the clay and quartz react on each other and bind the material together into a solid mass of great strength. This fluxing or vitrification is a time reaction which is favoured by high temperature, by fineness of grain, and by pressure which brings the particles closer together. Consequently, the coarser the grain the higher the softening temperature and the refractoriness. Grog or burned clay, being coarser than raw clay, has a higher softening point, so that the refractoriness of a clay may be raised by adding grog made of the same clay. Coarse-grained materials are less liable to crack when exposed to sudden changes of temperature but they are mechanically weak and liable to rapid destruction by abrasion or corrosion. To resist the latter, fine-grained materials are essential. They may be less refractory, but true refractoriness is often of secondary importance and must be sacrificed to secure greater durability under furnace conditions. Machine-made firebricks are commonly regarded as inferior to those made by hand. This is largely due to unfair comparison, the material for the latter being more suitable than that supplied to the machines. Pugged clay is often irregular in texture and machine-made bricks are frequently manufactured from clay which has not been allowed to stand long enough to mature properly. Uniformity of texture is so essential that its importance cannot be over-emphasised. The texture may be judged by polishing one face of a brick or other article, and cementing a glass plate on it by means of hot Canada balsam."—J. W. Mellor.—*Journal of the Society of Chemical Industry*, Dec. 15, 1916, p. 1218. (J. A. W.)

Thermal Conductivity of Materials Employed in Furnace Construction.—"The author reviews the work of Wologdine, Marshall, Dougall, Hodsman, and Cobb, and B. Dudley, and is dissatisfied with each of their methods. He proposes a method in which ordinary sized specimens (such as firebricks) are heated by immersing one face in a bath of molten metal heated electrically so as to secure a uniform temperature throughout the face to be tested, and a flow calorimeter consisting of numerous turns of piping attached to a water supply of constant temperature and pressure is applied to the cooler face of the specimen. The rate of flow of the water is adjusted to produce an equal temperature rise in equal intervals of time. The temperature of the cooler face of the specimen is measured by means of differential couples of 6 pairs of copper-constantan immersed in the flowing water. The calorimeter is fitted with a guard ring which is separated from it by a narrow gap about 1 mm. wide filled with mica plates set on edge. This arrangement gave results which agreed with those obtained by placing the hot face of the specimen on an iron plate, which formed one of the walls of a large muffle, and determining the temperature of this face by means of a bare nickel copper-nickel couple cemented into it, but the use of a molten metal bath gave more concordant results. In working with thick samples it is necessary to allow ample time for equilibrium to be attained: this sometimes takes several days. Tests on a brick made of diatomite bonded with a little clay showed that the conductivity in C.G.S. units between 105° and 502° C. rose steadily from

0·000310 to 0·000161. Tests on a slag-wool mat (CaO 48, SiO_2 43%) showed a conductivity between 194° and 476° C. of 0·000191 to 0·000342. The conductivity-temperature graphs of both diatomite and slag wool were straight lines. By the same method, the conductivity of a mixture of basic carbonate of magnesium with 15% of asbestos (such as is used for covering steam-pipes) is about 0·00015 between 20° and 350° C. At the latter temperature the carbonate decomposes, and at a dull red heat the mixture falls to a loose powder of double the conductivity."—E. Griffiths. —*Journal of the Society of Chemical Industry*, Dec. 15, 1916, p. 1219. (J. A. W.)

A New Absorbent for CO_2 in Steel Analysis. —"A new absorbent for carbon dioxide, termed 'soda asbestos' is prepared by mixing a solution of 500 gm. of sodium hydroxide in 500 cc. of water with 1 kilo. of pulverised sodium hydroxide, and adding shredded asbestos gradually, with stirring, until the mixture appears not to be capable of wetting more asbestos. The mass is heated at 150°–180° C. for 4 hours, with addition of more asbestos from time to time, then cooled and ground till most of it passes a 10 mesh sieve. A quantity of this absorbent sufficient to fill the tube described above, will absorb 8—10 gm. of carbon dioxide."—G. L. Kelley, *J. Ind. Eng.*, 1916, *8*, 1038-1039.—*Journal of the Society of Chemical Industry*, Dec. 15, 1916, p. 1237. (A. W.)

Lead Molybdate.—"Lead molybdate, precipitated from ammonium molybdate solution by the addition of lead nitrate solution, is more granular and much less bulky than when lead acetate solution is used as the precipitant: the precipitate obtained with lead acetate may, however, be rendered granular by adding a small amount of nitric acid to the ammonium molybdate solution. Freshly precipitated molybdate is fairly soluble in nitric acid, and slightly soluble in ammonium acetate and sodium acetate solutions, but the solvent action of the small amount of nitric acid used to obtain the precipitate in a condition suitable for filtration may be counteracted by subsequent neutralisation. In the presence of an excess of ammonium molybdate, lead molybdate forms a colloidal solution: the addition of nitric acid reprecipitates the lead molybdate. To determine molybdenum in a soluble molybdate, a quantity of the salt corresponding to about 0·4 gm. MoO_3 is dissolved in 180 cc. of water, a few drops of nitric acid are added, and, to the boiling solution, 4% lead nitrate solution is added, drop by drop, until the addition of a further drop causes the milky mixture to become visibly clearer. The boiling is continued for another 3 mins., another drop, or more, of lead nitrate solution is added, followed by ammonia until the mixture is neutral, to litmus paper. The precipitate is collected, washed with 2% ammonium nitrate solution, dried above 100° C., and ignited at a dull red heat, and weighed $PbMoO_4 \times 0{\cdot}2616 = Mo$. This method may be used, conversely, for the determination of lead."—H. B. Weisser, *J. Phys. Chem.*, 1916, *20*, 640-662.—*Journal of the Society of Chemical Industry*, Dec. 15, 1916, p. 1237. (A. W.)

Volumetric Determination of Mercury.—"The method is based on the reduction of mercury salts to metallic mercury by means of formaldehyde in presence of potassium hydroxide. The mercury is treated with excess of a standard iodine solution, the excess of the latter over the amount required to convert the mercury into mercuric iodide being determined by titration with standard sodium thiosulphate solution. The method is rapid and gives very exact results, and is carried out as follows. One gram of the mercuric salt or of the mercuric chloride compress is treated with a little water and, if necessary, sodium chloride to dissolve the mercuric salt, the solution being made up to 250 cc. Fifty cc. of the liquid is mixed in a beaker with 5 cc. of formalin (about 40% aqueous formaldehyde solution) and 10 cc. of 33% sodium or potassium hydroxide solution, and the whole heated on a water-bath for a few minutes and then allowed to cool. The liquid is now neutralised with acetic acid and the precipitated mercury collected and washed. Filter and precipitate are shaken with 100 cc. of water slightly acidified with acetic acid and exactly 20 cc. of $N/10$ iodine solution until all the mercury has passed into solution as mercuric iodide, and the excess of iodine is estimated; 1 cc. of $N/10$-iodine = 0·01 gm. of mercury or 0·01355 gm. of mercuric chloride." G. Adanti, *Boll. Chim. Farm.*, 1916, *55*, 553-551: *J. Chem. Soc.* 1916, *110*, ii., 579-580.—*Journal of the Society of Chemical Industry*, Dec., 30, 1916, p. 1258 (A. W.)

Separation of Lithium from Other Alkali Metals.—"The author makes use of alcohol and ether to precipitate sodium and potassium chlorides from an aqueous solution containing them together with lithium chloride. The mixed alkali chlorides are dissolved in a minimum amount of cold water, treated with one drop of concentrated hydrochloric acid, and 20 cc. of absolute alcohol added gradually. The sodium and potassium chlorides should come down in a uniform granular condition. 60 cc. of ether is added, and the mixture allowed to stand for about 5 minutes, filtered through a weighed Gooch crucible, and the containing vessel thoroughly washed with a mixture of alcohol 1 part and ether 4 to 5 parts. The precipitate is well washed, and the filtrate evaporated to dryness, and the residue treated with 10 cc. of absolute alcohol, if necessary warming to complete solution. 50 cc. of ether and one drop of concentrated hydrochloric acid are then added, the mixture allowed to stand for ½ hour, the precipitate collected in the same crucible as used for the first precipitate, washed with ether-alcohol mixture as before, dried, gently ignited, cooled, and weighed. The ether-alcohol solution of lithium chloride is evaporated on a steam bath, the residue dissolved in water, treated with a slight excess of sulphuric acid, transferred to a weighed porcelain or platinum dish, evaporated on a steam bath, and ignited. If charring occurs, the treatment with sulphuric acid and ignition are repeated. In an optional method for the lithium, the ether-alcohol solution is evaporated on a steam bath and the residue dried at 110° C. for 15—20 minutes, treated with 5—10 cc. of alcohol, warming if necessary, the solution diluted with about 50 cc. of water, and filtered if necessary through a Gooch crucible. The acid solution is titrated with $N/10$ alkali, the chlorides precipitated as silver salt, and from the weight of the latter is deducted the amount corresponding to the hydrochloric acid determined by titration. If the total quantity of mixed chlorides is greater than 0·5 gm., proportionately larger quantities of solvents are necessary in the first precipitation, but more accurate results are obtained when the total chlorides do not exceed 0·5 gm."—S. PALKIN, *J. Amer. Chem. Soc.*, 1916, *38*, 2326-2332.—*Journal of the Society of Chemical Industry*, Dec. 30, 1916, p. 1273. (A. W.)

METALLURGY.

FLOTATION PROCESSES.—"The flotation process for the concentration of ores is a method by means of which one or more of the minerals in the ore (usually the valuable ones) are picked up by means of a liquid film and floated at the surface of a mass of fluid pulp. Here they are separated from the other minerals, which remain immersed in the body of the pulp. In general, the minerals which are floated are sulphides of metallic lustre, but some other minerals of metallic lustre such as graphite and some sulphides with adamantine lustre, such as sphalerite and cinnabar, are amenable to treatment by the process.

The importance of flotation lies in the fact that it is primarily a 'slime process,' by means of which the particles of valuable mineral, too fine for efficient gravity concentration, are saved with a high percentage of recovery. Recoveries in the mills treating low-grade copper sulphide ores have been advanced 10% to 20% by the installation of the process, and similar increased savings have been accomplished by the same means in mills treating sulphide ores of zinc and lead.

When finely ground ore containing sulphides mixed with a silicious or earthy gangue is brought gently on to the surface of a body of water, in a direction forming an acute angle with the surface of the water, a considerable portion of the sulphide constituent of the ore floats on the surface of the liquid, while the gangue sinks. This is the so-called film flotation, exemplified by the Wood and Macquisten processes

When gas bubbles are introduced into a fluid pulp composed of finely ground ore, water to which has been added (1) a small amount of certain oils, or (2) a small amount of certain acids or acid salts, or (3) a small amount of certain alkalies or alkaline salts, or (4) a small amount of a mixture of oil with acid or alkali, the sulphide particles in the ore are brought to the surface on the gas bubbles. These collect in a froth heavily laden with sulphide particles. The gangue particles are not brought up by the bubbles, but remain in the mass of the pulp. This is the so-called froth flotation. Its variations, acid-froth, agitation-froth, and pneumatic-froth processes are discussed in detail later.

The points to be explained in the operation of these processes are: (1) The flotation of solid particles in a liquid the specific gravity of which is less than that of the solid; (2) the preferential flotation of the sulphide portion of the mass; (3) the functions of the reagents used.

Theory.—The theory here presented in explanation of the points listed in the preceding paragraph appeals to the following physical phenomena: Surface tension, adsorption, adhesion, and viscosity. The first three of these are closely related.

Surface Tension.—Every liquid surface in contact with a gas or its vapour behaves as if it were under tension. The value of this contractile force per unit width can be measured. Its value for water, 74 dynes per centimetre, is higher than for any other well-known liquid. (Liquid metals and fused salts are, of course, excepted.) This fictive tension is a convenient conception for many discussions and may be explained in terms of the intermolecular attractions of the substances forming the boundary.

We find that the invariable effect of oiling a solid surface is to reduce the surface tension of the water due to contamination by the oil. This is further discussed later.

The conclusions forced by observation are:—

1. That water has a smaller tendency to displace air on the surface of sulphide minerals than on the surface of gangue minerals.

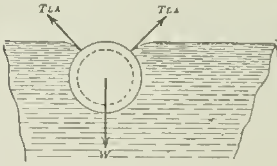
2. That the tendency of oil to displace air is greater at the surface of sulphide minerals than at the surface of gangue minerals.

3. That oil tends to displace water on the surface of sulphides and that water tends to displace oil at the surface of gangue minerals.

4. That water displaces air more readily on an oiled solid surface than on a clean surface of the same solid.

These conclusions suggested the following confirmatory experiment.

A ring, 6.17 cm. outside diameter and specific gravity of 1.38, made of aluminium tubing, 0.63 cm. diameter, was cleaned and floated without trouble on the surface of pure water. The shape of the water surface at the air-water contact is shown in Fig. I. The ring was then oiled slightly. The air-water contact angle was reduced, as shown in Fig. II., to such an extent that it was impossible to float the ring. The same was true, as might be expected, when a cylinder of aluminium replaced the ring. A similar cylinder of glass tubing exhibited such a small air-water contact angle that it could not be floated.



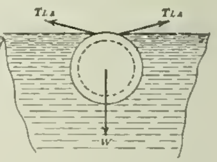


FIG. I.—*Shape of Water Surface at Air-Water Contact. The Aluminium Tubing Unoiled.*

FIG. II.—*Change of Conditions due to Oiling the Aluminium Tubing.*

Adsorption.—Adsorption of the gas at a gas-liquid surface is indicated:

1. By the effect on the surface tension. The surface tension of a freshly formed mercury surface does not change in a vacuum, but falls off in the presence of different gases for about an hour. Certainly the density of a liquid cannot be constant at the boundary, but must go over continuously into that of the gas.

2. By the increase in the solvent power of the surface.*

3. In the case of contaminated liquids, by the concentration of one or more of the components of the liquid at the gas-liquid surface. Every unit area of such a boundary possesses a definite potential energy which always tends to a minimum. If, therefore, the surface tension of a solution depends upon the presence of any component, such a change of concentration of that component will occur as will reduce the potential energy, *i.e.*, the

---

*Pockels: *Nature*, Mar. 12, 1891, p. 439.

interfacial tension. In other words, any component which reduces surface tension will be found in excess at the surface of a solution. For example, the surface tension of water is greater than that of alcohol. Experimentally, a drop of alcohol on a thin film of water rapidly reduces the surface tension of the water and the latter draws away from the alcohol. On the contrary, a drop of water on a thin film of alcohol spread over glass does not at once diffuse into the film but remains gathered in a heap. Such diffusion would increase the surface energy of the system, hence the water concentrates away from the gas-liquid surface. The greater viscosity of the surface of a solution above that of the bulk, or of that of a pure liquid, has long been recognised[†] by its damping effect upon a swinging magnetic needle and may properly be ascribed to gas-liquid adsorption. Closely connected with this is the formation of elastic solid skins or very viscous layers at a free surface, as, for example, in the case of solutions of peptone and dyestuffs.

The presence of such a viscous layer at an oil-water interface is easily shown by pouring any clear oil, kerosene, liquid vaseline, etc., on to water and then bubbling a gas through the water. The interface has all the appearance of an elastic skin. Bubbles rising through the water and striking the under side of the interface stretch the film, and rising farther drag away a mass of water surrounded by this viscous layer.

Viscosity.—A marked increase in the viscosity of interfacial films is produced by the presence of finely divided solid matter. This increase is apparent in the experiment just described when finely powdered sulphide is thrown into the oil and allowed to settle to the interface, where it becomes entangled in the film. When gas bubbles are introduced, as before, the return water drops, coated with a film containing the solid particles, are much more irregular in shape than previously, and their coalescence after reaching the interface requires days or weeks.

Summary.—The potential at a gas-sulphide contact is less than at a gas-gangue contact; hence gas bubbles will cling with greater persistence to sulphides than to gangues.

Oil replaces water at the surface of sulphide minerals.

Water replaces oil at the surface of gangue minerals.

Water replaces gas more readily at an oiled surface of a solid than at a clean surface.

The addition of any contaminant to water lowers the surface tension.

In any body of contaminated water there will be a concentration of the contaminant at the air-liquid surface.

Adsorption at a gas-liquid surface lowers the surface tension and increases the viscosity.

Adsorption at a liquid-liquid surface produces a film whose viscosity is higher than that of the bulk of either liquid.

The presence of finely divided solid matter in a film markedly increases the viscosity of the film.

Application to Commercial Flotation Processes.—Film Flotation.—Pulp with or without oil or acid is fed gently, at an acute angle, on to the surface of a body of still water. The sulphide floats and the gangue sinks.

Possible cases:

Case 1.—Sulphide, gangue, water.

Case 2.—Sulphide, gangue, water, oil.

Case 3.—Sulphide, gangue, water, acid.

Case 4. Sulphide, gangue, water, acid and oil.

Case 1. Sulphide, Gangue, Water.—The governing factor in the initial flotation of the sulphide and immersion of the gangue is the difference in the air-water contact angle with the sulphide and gangue surfaces respectively. If the difference is great, as in the case with galena and quartz, good separation is obtained. After a considerable amount of sulphide has been floated, if the surface flow is sufficiently impeded, the particles congregate into clumps by the well-known phenomenon of apparent attraction of floating particles,[*] a scum is formed (whose viscosity and resistance to rupture are many times greater than that of the original water surface) and the floated particles are rendered more immune to immersion.

Case 2. Sulphide, Gangue, Water and Oil.—When oil is added in this process the phenomena are entirely different from the simple film flotation of Case 1. The oil concentrates at the surface since such concentration reduces the surface energy of the system. This adsorption of the oil at the gas-water surfaces causes the formation of a viscous film. When the mixture of sulphide and gangue is introduced at the surface, the sulphide particles tend to migrate into this layer and the gangue particles migrate into the water, for a sulphide particle in contact with oil represents the condition of least potential energy which is possible for the sulphide particle to assume in the system of oil, sulphide, and water. Likewise the gangue particle surrounded wholly by water represents the condition of least potential energy for the gangue particle to assume in this system. In this case also, the formation of a scum of floated sulphide increases the stability of the float.

Case 3. Sulphide, Gangue, Water and Acid.—The effects of acid are: (*a*) to diminish the surface tension of the liquid, (*b*) to diminish the gas liquid contact angle, and (*c*) to increase the viscosity of the gas-liquid surface. The diminutions of (*a*) and (*b*) are more marked with gangue minerals than with sulphides. The result is that cleaner concentrate may be expected than in either of the previous cases, but at the expense of richer tailing.

Case 4. Sulphide, Gangue, Water, Oil and Acid.—In this case a combination of results such as can be predicted from the preceding cases is obtained.

Froth Flotation.—In order to explain froth flotation it is necessary and sufficient that the gas of each bubble shall be inclosed by a film of contaminated water which shall possess the following characteristics:

1. Low surface tension.
2. High viscosity.
3. A variable concentration of the contaminant (re-agent).
4. A preferential adhesion of the bubble film to the sulphide mineral compared to that for the gangue minerals.

The durability of a liquid film depends upon one or more of the following conditions:

1. A low surface tension which is locally variable so as to produce stable equilibrium.
2. High viscosity, which may pass over into.
3. Chemical irreversibility and the production of solid skins.

Pure liquids do not foam: for example, water or alcohol. The reason is obvious. As the film is thinned out by stretching or by draining away of the liquid, the surface tension is reduced at some part below the general constant value. As soon as this begins the thicker and more powerful parts of the film drag away from the weakened parts which at once completes the rupture. But the most important condition for durability is some means by which the equilibrium of the forces at any point in a film may be restored, when a variation of some of the forces occurs. In the case of a compound liquid or solution this is effected by the adsorption or change of concentration of one or more of the components in the film.

[†] Daniels: *Physics*, p. 258, Fr., p. 76.

[*] Hastings and Beach: *General Physics*, p. 156.

The surface tension of a solution is in general notably different from that of the pure solvent, and in case of water, whose surface tension is the greatest of any liquid with which we are concerned, even a minute trace of impurity is sufficient to lessen its surface tension considerably.

Consider a film of water stretched on a vertical ring of wire. If the surface tension remained constant, as it does in the pure liquid when the thickness exceeds 0·000001 cm., the weight of the lower part would stretch down the upper part until it broke. If the water contains some component whose depletion at the weaker points increases the surface tension, equilibrium will be preserved. In the stretching of the film, and in the general running away of the liquid between the surfaces of the film, which reduces the total available amount of the contaminant, such decrease of the concentration and increase of surface tension does occur, and the film remains stable under a considerable variation of external conditions. The formation of bubbles as a result of this variation of surface tension alone is well exemplified by a simple aqueous solution of soap or of acetic acid. The running out of the liquid between the two surfaces is greatly retarded by the viscosity of the liquid, a property which may be largely influenced by the surface adsorption of one or more of the components.

When, then, gas bubbles are introduced into a liquid pulp where oil is present there is formed about each bubble a liquid film whose surface tension is less and whose viscosity is greater than that of the bulk of the liquid. Some of the solid of the pulp move into the film and are raised to the surface with the bubble. Since there is a concentration of oil in the film, and since the diminution in potential energy at an oil-sulphide contact is greater than at a water-sulphide contact, the contaminated layer replaces the water on the sulphide surface and the sulphide moves into the bubble film, while the gangue, on which water displaces oil, remains in greater measure in the body of the pulp. The bubbles, therefore, as they arrive at the surface, carry an excess of the sulphide minerals. Upon their arrival at the surface, the bubbles of the contaminated liquid persist, owing: (1) to their lower surface tension; (2) to their ability to adjust this tension to a state of stable equilibrium; and (3) to their greater viscosity which is markedly increased by the presence of the solid particles.

Mechanical-Agitation Froth Process. — Sulphide and gangue minerals are beaten up with water and oil, with or without acid, then allowed to flow into a box containing a considerable body of liquid nearly at rest. Bubbles coated with a preponderance of sulphide particles float to the surface and form a heavy, persistent froth. The gangue particles sink.

Two cases arise:

Case 1.—Sulphide, gangue, water and oil.

Case 2.—Sulphide, gangue, water, oil and acid.

Case 1. Sulphide, Gangue, Water and Oil.—When this pulp is beaten, air is mechanically entrapped in the form of bubbles. At the surface of every bubble in the mass there is a gas-contaminated-liquid contact which results in the adsorption at this surface of the contaminant, oil, and the production of a viscous film into which the sulphide particles, circulating in the mass, pass with a diminution in the potential energy of the system. The result is that in a very short time after the air bubble is entangled in the pulp, it is surrounded by a viscous sheath composed of an oil-water interfacial film in which are entangled a large number of sulphide particles. The presence of the solid particles greatly increases the viscosity of the bubble sheath. When the solid-coated bubble arrives in the settling box or spitzkasten it rises to the surface. Here the bubble persists, or, bursting, transfers its load to other bubbles. This bubble persistence is due to a combination of several factors. The oils used have, in general, a slower evaporation rate than water. The tension of the bubble film is lower than the tension of a pure water bubble. The bubble has the power of adjusting itself to its tension, within limits, without bursting. The presence of the large amount of solid matter enormously increases the viscosity of the film.

Case 2. Sulphide, Gangue, Water, Oil and Acid.—The addition of acid has the two-fold effect of further lowering the surface tension and increasing the adhesion ratio $\frac{\text{oil-solid}}{\text{water-solid}}$. The result is, in general, cleaner concentrate with or without an increase in the sulphide content of the tailing.

Heating the pulp has, in some cases, a beneficial effect. Where this is true it is probably due to (*a*) decreased surface tension and consequent increased stability of the froth; (*b*) increased number of air bubbles formed by the air released from solution; (*c*) in the case of viscous oils, the greater area over which oil is spread and consequently the greater number of bubbles with a viscous oil-water interfacial film; (*d*) probable increase in solubility of the oil and consequent greater diffusion, resulting in more widespread adsorption in bubble films.

Pneumatic Froth Process.—Sulphide and gangue minerals mixed with water and oil, with or without acid, are run into a vat with a porous bottom through which air is forced. The air bubbles rise to the surface with a coating of solid particles, preponderantly sulphide, while the gangue particles sink.

The principles involved in this method are the same as explained in the agitation-froth process. The only difference is in the method of introducing air. The result of this difference is that the bubbles in the pulp are much larger than in the agitation froth method; they arrive at the surface less heavily loaded in proportion to their area; the bubble films are, therefore, less viscous, and the froth less persistent.

Potter-Delprat Process.—Sulphides and carbonates, with or without other gangue minerals, are treated with hot, dilute sulphuric acid. Bubbles of carbon dioxide and hydrogen sulphide are formed which rise to the surface with a sulphide coating and there form a froth. In this method as in the other froth methods, gas bubbles are formed which are surrounded by films of contaminated water, the contaminants in this case being sulphuric acid, lead sulphate, calcium sulphate and other salts formed by the action of the sulphuric acid. The films have a higher viscosity and a lower surface tension than is possessed by the bulk of the liquid. The sulphides move into the bubble films because the system composed of sulphide and this contaminated layer has a lower potential energy than the system composed of the pulp in the bulk of the liquid. The writers at first suspected that the selective action in this case might be due to preferential gas adsorption at the gas-sulphide contact, as opposed to a gas-gangue contact, but microscopic examination of mineral froths collected from the process showed that the solid particles in the froth were completely within the films and at no point in contact with gas. The persistence of the froth is due to the factors explained in connection with the other froth processes.

While the writers have made no appeal to electrostatic forces or to colloidal phenomena in this discussion, they realise that the potential energy existing at the contact of dissimilar substances may well include electrical forces and that migration of the suspended solid particles under the influence of electrical charges, similar to the migration of colloids, may account for some of the selective action of the bubble films. But the agitation of the pulp in the mechanical- and pneumatic-froth processes and the generation of carbon dioxide gas on carbonate particles in intimate contact with sulphides in the acid-froth process, are sufficient, in their opinion, to bring every sulphide particles into contact with a bubble film. Once in contact, the preferential adhesion of the contaminated layer to a sulphide surface in the presence of water is sufficient to account for the persistent attachment of the sulphides to the bubble films, while on the other hand, the replacement of gas or oil by water on the surface of gangue particles explains the wetting and continued immersion of the latter."—A. F. TAGGART and F. E. BEACH.—*Metallurgical and Chemical Engineering*, Nov. 1, 1916, p. 518. (H. A. W.)

ROCK CRUSHING. — "*Aim of Rock-Crushing Experiments.*—The aim of the laboratory experiments described in this paper was twofold:

1. To measure as accurately as possible the maximum amount of crushing that can be effected by 1 h.p. acting for 24 hours, by the two proposed methods for measuring the amount of crushing, namely: (*a*) by Rittinger's method; (*b*) by Stadler's method, based on Kick's law.

2. To show, if possible, that by one of these methods, the amount of crushing produced by 1 h.p. in 24 hours is a constant amount throughout a wide range in the diameter of the piece crushed, and that by the other method, the amount of crushing is a variable quantity over the same range of diameter; or else show that neither of the proposed methods for measuring the amount of crushing indicates a fixed relation between power and crushing and consequently a new method for computing this amount will have to be found to permit the establishment of a law of crushing.

Experimental Methods.—Testing machines, calorimetric methods and commercial types of rock-crushing machines were considered with reference to their value for measuring power used in crushing. The following electrically driven crushing machines, installed and available in the McGill Ore-dressing Laboratory and which had been used in previous rock-crushing tests, on the whole seemed especially suited to the investigation: (1) Comet 'A' crusher; (2) 7×9 in. Dodge crusher; (3 10×16 in. rolls. In later tests a 3½ ft. Huntington mill was used.

Rock Used. In all the series of tests, except one, the rock crushed was a tinguaite—an intruded eruptive obtained from a local quarry. It is a hard and brittle rock, with a tendency to break rather more easily in one plane than in another at right angles to it. It, therefore, is inclined to break in slabs, although the fractured pieces are always irregular in shape.

1914 *Crushing Tests.*—In 1914, three series of tests were made to measure the work done per 'apparent effective horsepower in 24 hours.' In the first series the laboratory Comet 'A' crusher was used; in the second series, the Dodge crusher; and in the third series, the rolls.

In certain respects the results of these tests were unsatisfactory, but the data obtained indicated strikingly the probability of a fatal error in Stadler's method and a degree of reliability in Rittinger's. The figures showed an enormous variation in the amount of crushing done by a measured horsepower through a wide range in diameter when calculated by Stadler's method, based on Kick's law, and a remarkable constancy when calculated by the law proposed by Rittinger in 1867. The comparative figures in Table I. justify fully the indicated, but not necessarily proved, outcome of the whole investigation.

TABLE I.—*Summary of the Most Efficient of the 1914 Tests.*

Test No.	Crusher.	Diameter of Piece Crushed, Inches.	Work Done per A. E. H.p.* in 24 Hr.	
			Measured in Stadler E. U.†	Measured in Rittinger S. U ‡
6	Gyratory	3·50	710	947
27	Dodge	1·20	520	1,030
34	Rolls	0·50	286	1,128
41	Rolls	0·29	138	1,000
47	Rolls	0·18	68	1,022
48	Rolls	0·11	89	1,187
49	Rolls	0·07	52	823

Total range ... ... 50 diameters.
Range in roll tests ... ... 7 diameters.

* Apparent effective horsepower. † E. U. = energy units. ‡ S. U. = surface units.

1914-1915 *Rolls Tests.*—In the fall of 1914, the fourth series was commenced to investigate in more detail the effect of 'tonnage' and 'work done per ton' before adopting a set procedure for the final series with rolls.

The decrease in efficiency which results by increasing the feed tonnage, or by increasing the crushing work per ton, for sizes 0·46 in. in diameter and upward was clearly indicated by the results obtained.

The sudden increase in efficiency, when the feed diameter is reduced to 0·30 in., is explained by the marked change in the sound and vibrations emanating from the machine. When crushing

0·46 in. feed at the 30 ton rate, the vibrations in the laboratory concrete floor were perceptible 20 ft. distant from the rolls. When crushing 0·30 in. feed, the floor vibrations practically disappeared, and there was a marked diminution in the smashing shocks, resembling a series of explosions, which were so pronounced during crushing of the larger feeds. In the next and succeeding smaller sizes the characteristic sound effect may be described as being in the nature of a steady grinding noise, indicating that a more uniform pressure replaces the fluctuating and violent forces transmitted to the journals during the crushing of the larger pieces. That there should be an enormous decrease in machine efficiency under the stated circumstances, is in the writer's opinion opposed to reason and common sense, and yet that is the one and only conclusion that can be reached by acceptance of Stadler's theory based on Kick's law, as will be apparent by examination of the data in Table II. and Fig. I.

TABLE II.—*Summary of Results of 1914-1915 Rolls Tests.*

Test No.	Remarks.	Diameter Feed, Inches.	Tons Crushed in 24 Hr.	Work Done, per Ton, Rittinger S. U.	Work Done per A. E. Hp.	
					Stadler E. U.	Rittinger S. U.
50	…………………	1·00	12·2	6·9	623	1,198
53	…………………	0·70	10·2	9·8	472	1,192
60	…………………	0·46	5·8	20·6	272	1,097
79-88	Average 9 tests*	0·30	28·7	21·3	190	1,002
89-93	Average 5 tests	0·19	31·3	30·9	150	1,115
94-97	Average 4 tests	0·12	33·8	22·6	100	1,051
98-101	Average 4 tests	0·08	34·5	31·8	82	1,028
102-105	Average 4 tests	0·05	31·6	21·5	77	1,137
106-109	Average 4 tests	0·03	29·8	28·0	77	1,250
	Range	…	…	33 diameters.		
	Average R.S.U.	…	…	1,120		

* Test 86 excluded.

The Stadler energy unit varies depending not only on the diameter of the feed, but on the work done per ton as well. In tests 50-53 the 'work done per ton' is less than in the remaining tests (see Table II. and Fig. I.) and the Stadler efficiency increases correspondingly.

It follows that there are an infinite number of values of this apparently misnamed 'energy unit of crushing,' consequently it is not a unit indicating a fixed relation between power and crushing when the material crushed is rock, however applicable it may or may not be in estimating the power required to crush an ideal and more or less imaginary substance. The unavoidable conclusion to be drawn from the experiments is that the Stadler energy unit is of no value in determining the relative efficiencies of various types of rock-crushing machines. For a single machine, crushing feed of limited range in diameter with only a small variation in the work done per ton, Stadler's theory, based as it is on one of the manifestations of crushing, shows the character of the changes in efficiency produced by changes in adjustment, but the Rittinger system, even if it fails to conform with a law, is preferable by reason of its greater sensitiveness to small variations in the amounts of crushing.

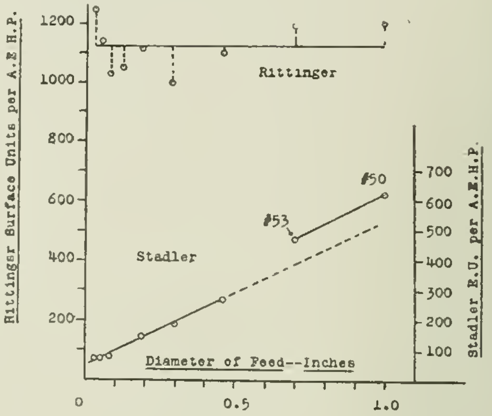


FIG. I.

Power in Fine Crushing.—The sudden increase in the work per apparent effective horsepower in the last four tests (see Table II.), indicated the importance of investigating the relation of power and the crushing of rock particles of very small diameter. Some preliminary work convinced the author that a Huntington mill was admirably suited for the investigation and this machine, with some modifications, was accordingly used.

TABLE III.—*Summary of Average Results, Huntington Mill Tests.*

Item No.	Remarks.	Grade.	Diamond Feed, Inches.	Work Done per A. E. Hp.	
				Stadler E. U.	Rittinger S. U.
114-115	…………………	+ 20	0·031	55·0	1,590
116-119	…………………	− 30	0·020	47·5	1,860
120-122	…………………	+ 40	0·014	45·5	2,030
125-127	…………………	− 60	0·009	34·2	1,970
128-129	Test 130 excluded	+ 80	0·007	28·1	1,910
131-132	…………………	+ 100	0·005	20·2	1,800

Range of diameter tested … … … … 6.

The results in Table III. show the characteristic drop in Stadler units per apparent effective horsepower, although the range of diameters tested is not large. However, many more experiments would be required to determine the effect of alterations in tonnage, percentage of water in pulp, speed of machine, etc.

Test 116 was made to obtain an indication of the effect of a reduced tonnage. The number of Rittinger units appears to increase, but several check tests would be required to form a definite conclusion.

Considered as a whole, the results are in closer agreement with Rittinger's theory than could be expected, when two obstacles which conspire to defeat the purpose of the investigation are taken into account. One, is the difficulty of measuring the power used only in crushing. The second has to do with the measurement of the surface in the −200 grade. Nobody has yet made a reliable measurement of this, and it is probable that it is a variable factor. For the −200 grade, Stadler's ordinal number 28 was adopted, for although it was realised that it was not necessarily an accurate estimate of the average volume of the particles it was supposed to represent, it would at least serve to make the comparison as fair to one as to the other theory. The corresponding Rittinger number is 780 which was adopted. It is probable that the average factor is appreciably greater than 780.

If in going from coarse to fine crushing there is a considerable decrease in surface in the −200 grades, the results tabulated in this paper would be appreciably affected, although the effect of such a variation would be more disastrous to Stadler's theory based on Kick's law than to Rittinger's, and the Stadler units per apparent effective horsepower might in consequence approach perilously near to zero.

Crushing Tests Using Quartz.—In this investigation, the desirability of crushing a quartz gangue was recognised as being of more interest to those engaged in practical work; unfortunately, however, none was obtainable locally, and tinguaite was employed for the experiments. It was feared that to some extent the habit of fracture of tinguaite might have prejudicially influenced the results obtained, hence upon the conclusion of the Huntington mill tinguaite tests, a series of grades of quartz sand was prepared and used to determine this point.

Convincing evidence was furnished by the results obtained that the relation between power and crushing indicated by the tinguaite tests remains unchanged when the rock crushed is quartz, excepting that the crushing force is less.

Conclusions.—When it is considered that Gates, using a testing machine, obtained similar results for three entirely different rocks, a sufficient amount of experimental data now seems available to justify the following conclusions:—

1. That in the reduction of any given rock there is a constant relationship between the power applied and the crushing effected.

2. That Rittinger's theory appears to conform agreeably with this relationship.

3. That Stadler's theory based on Kick's law does not so conform."—J. W. BELL.—*Trans. Amer. Inst. Min. Eng.*, Feb., 1917, pp. 171-176. (H. A. W.)

SURFACE TENSION AND COHESION OF METALS.—Summary of paper by Sydney W. Smith, D.Sc., A.R.S.M. (London), on "Surface Tension and Cohesion in Metals and Alloys," presented at the Annual General Meeting of the Institute of Metals, held in London on Wednesday, March 21st, 1917.

"The author refers to a previous communication, made by him in 1914, in which he described a method of measuring the surface tensions of molten metals based upon the observation that capillary depressions occur in the surfaces of molten metals when carbon tubes of fine bore are plunged vertically into them. These depressions were found to follow the general law by varying in depth inversely as the diameter of the tube, and to be analogous, in every way, to the depressions which have long been known to occur under similar conditions in liquid mercury.

The property of surface tension, being the result of internal molecular forces which are unbalanced at the surface of a liquid, is now considered in relation to the internal forces of cohesion in the solid state, and from this point of view it is regarded as being an index of cohesion.

The continuity of properties in the liquid and solid states has been examined by Traube in relation to Van der Waal's equation, an expression in which Boyle's Law is extended to take into account the forces of molecular cohesion in modifying the simple gas relation, PV=a constant and originally applied to gases under considerable compression. As the result of the application of this equation to the solid state certain figures have been given by Traube for the internal pressures or internal cohesions of the pure metals, based upon their atomic volumes and co-efficients of expansion.

These figures have now been compared with the surface tensions in the molten state of those metals which have so far been examined, and, with the exception of aluminium, they show a comparatively simple linear relation. From this it is concluded that surface tension in the molten state may be regarded as an index of cohesion in the solid state.

The relation of these internal pressures to the compressibilities of metals as determined by T. W. Richards is next discussed. By considering atomic compressibilities as deduced from Richard's values for unit volume, Traube showed that, for fourteen metals in the solid state, the product of the internal pressure and the square root of the atomic compressibility is roughly a constant. The significance of this relation is discussed with regard to the hardness produced in metals by cold work, and it is suggested that a closer scrutiny should be made of the small changes of density which occur as the result of such treatment.

The second portion of the paper deals with certain aspects of cohesion when considered in relation to the miscibility of metals when alloyed. Indications are given of the direction in which the determination of the surface tensions in the molten state may throw some light on problems which are intimately dependent on cohesion.

Consideration is given to the occurrence of "liquidation" resulting from limited miscibility even in cases in which the components are regarded as forming complete series of solid solutions. An explanation of this behaviour is offered, based upon the foregoing considerations.

Certain conclusions are drawn as to the effects of the relative internal pressures of the components of certain alloys in determining their hardness, and the application of these views is made to certain cases.

The paper concludes with a bibliography relating to the questions which have been discussed."—S. W. SMITH, D.Sc.—*Inst. of Metals.* (H.A.W.)

A NEW METHOD OF ZINC PRECIPITATION.—"With the object of eliminating the necessity of using zinc in the form of dust or shavings for the precipitation of gold and silver from cyanide solutions, a new method of precipitation has been devised and a machine invented for its practical application. The apparatus can be used for precipitating other metals from their solutions also, particularly for precipitating copper with iron.

The aim of the invention is twofold—first, to apply the zinc precipitant in its cheapest form, and second, to obtain a precipitate free from impurities, especially from zinc.

The basic idea is to pass the pregnant solution over and through a quantity of small balls of zinc, with other small pieces of zinc, the flow of the solution and the rolling action of the pieces of zinc combining to remove the precipitate from the zinc, the separation of the precipitate from the barren solution taking place after leaving the machine.

The experimental machine first constructed had a spiral rib inside a pipe of 12 in. diameter, inclined at 30° and acting on the principle of an Archimedean screw, so that as the entire pipe slowly revolved, the zinc balls rolled around on the spiral rib and advanced toward the upper end of the main pipe. The lower end of the main tube, as shown in Fig. I., had the spiral rib high enough to touch an inner tube which had a closed top, so that the lower part of the main tube had a spiral channel between the main and inner tubes, defined by the spiral rib. The spiral rib at the top of the main tube, as shown in Fig. I., was so shaped that it delivered the zinc balls, as they moved along the upper end of the spiral rib, into a small central pipe, down which they ran to the bottom of the machine, where they again started rolling up the spiral rib toward the top. The zinc balls were removed from the solution by the spiral rib just before they were delivered into the small central pipe, and no solution flowed down this central pipe.

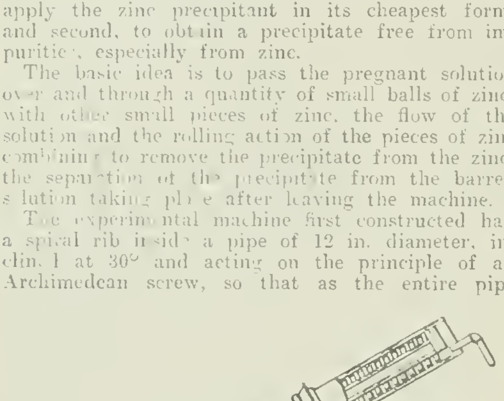


FIG. I.—*Sectional View of the Conklin Precipitator.*

The main part of the tube, above the inner tube, called the head of the machine, was kept fairly well filled with zinc balls and pieces of zinc of other shapes, only the balls rolling up the spiral rib and making the circuit of travel, while other shaped pieces or very small balls, which accumulated as chemical action took place, remained in the head, where the action of precipitation was most intense and where they were finally completely consumed. The slow rolling of the main tube gave sufficient agitation to the zinc and solution to provide contact of all the solution with zinc and precipitated the gold and silver. This rolling also loosened whatever particles of precipitate adhered to the zinc, so that all the precipitate was carried along with the solution as it left the machine, and the surface of the zinc was kept clean and chemically active.

Pregnant solution entered the machine at the top, flowed down through the slowly turning zinc, followed the spiral path around the inner tube, and left the machine through an outlet pipe so designed as to prevent any zinc from being carried out with the solution, which carried the precipitate with it. The continuous movement of zinc balls against the flow of the solution assured the contact of all the solution with zinc during its entire passage through the machine, and the accumulation of all irregular and small pieces of zinc in the head of the machine prevented any zinc leaving the machine with the precipitate.

Galvanic Action Prevents Silver Precipitation.—In experimental and testing work the first machine was made of iron and did not precipitate a silver cyanide solution. After much investigation it was discovered that when zinc is in contact with iron in silver cyanide solution, some galvanic action takes place which prevents the precipitation of the silver, although some iron cyanides are precipitated. This discovery explained a situation that had once arisen when attempting to precipitate with zinc shavings in iron boxes. It explains also why poor or no precipitation took place when passing solution through tube mills containing zinc. Probably zinc dust, when mixed with solution, is slightly affected by contact with the iron of pump and pipes, but so little of the dust is in actual electrical contact with the iron that the effect is inappreciable.

This discovery sent the iron machine to the scrap heap and led to the construction of a wooden one, with which proper precipitation took place. The first wooden machine was constructed entirely of wood, a 12 in. wooden-stave pipe having wooden spiral ribs, wooden pipe down the centre, wooden inner tube and discharge pipe, as shown in Fig. I. The wear on the wooden surfaces caused by the rolling zinc balls, although two months' test operation did not seriously impair the machine, was sufficient to shorten its life unduly. Machines will now be made with cast-zinc linings for the main wooden tube, the linings carrying the spiral ribs on their inner surfaces. This increases the area of zinc surface in contact with solution, and any wear or dissolving action on this lining simply aids precipitation.

The experimental work was carried on at a point where changes were very hard to make. For this reason, the zinc balls, although too large to provide sufficient zinc surface, could not be changed, and the insufficient zinc surface in the machine prevented a complete precipitation, although, after adjustment and some experience in operation, an assay of tail solution showed Au 0·006 and Ag 0·28 oz. per ton, compared with a pregnant solution entering the head of the machine assaying Au 0·046, Ag 2·30 oz. per ton.

The separation of the precipitate from the solution was effected by discharging the machine into a steep conical vat, as shown in Fig II., the Conklin Directed Thickener being used in the trial operation with satisfactory results, and filtering through bag filters. With this way no pumping was necessary, the pressure at the bottom of the conical vat being sufficient for filtering.

It was found that there was a tendency for the precipitate to redissolve, but by lining the vat with sheet zinc and constructing the inner cones of the Conklin thickener of sheet zinc, discharging all the solution through bag filters attached to the bottom of the vat, this re-solution was prevented. Apparently the presence of zinc in the mixture of barren solution and precipitate is sufficient to prevent re-solution, the sheet zinc in the vat showing no chemical action.

The precipitate consisted of about half each of the usual black precipitate and tiny bright metallic silver scales, without a trace of zinc. The average of six assays of precipitate showed Au 375·06 and Ag 19,322·8 oz. per ton, impurities consisting almost entirely of wood pulp worn off the machine and filtered out with the precipitate.

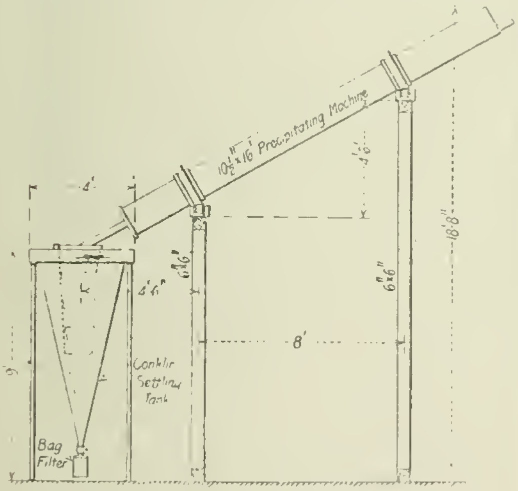


FIG. II.—*Precipitating Tube Discharging into Conical Thickener.*

In the newest machines, the increase of zinc surface, thanks to the cast-zinc lining and to the reduction in size of the zinc balls, should furnish practically complete precipitation.

This method of precipitation has several advantages, among which are the following: No excess of zinc is used, but just sufficient; zinc is used in its cheapest form; clean precipitate is produced, which can be melted with a minimum amount of flux, yielding the highest grade bullion and saving the cost and loss of acid during the treating and roasting of the precipitate. Since so much attention has been given to testing, and so much care taken to perfect the process, it seems reasonable to consider it practical."—H. R. CONKLIN.—*Engineering and Mining Journal*, Jan. 27, 1917, p. 195. (H. A. W.)

MINING.

ATMOSPHERES DEFICIENT IN OXYGEN.—*Effects on Small Animals and on Men.*—In studies of the composition of mine atmospheres as related to the health and safety of miners, the writers of this paper have observed that small animals, such as mice and canaries, are not quickly sensitive to atmospheres deficient in oxygen, and hence may not indicate to exploring parties in mines that the oxygen content of an atmosphere is dangerously low.

In conducting experiments atmospheres containing various percentages of nitrogen and oxygen were prepared in bell jars of 10 litres capacity. As a source of nitrogen a vat of the gas containing a small percentage of oxygen was used. The atmosphere in the vat contained by analysis 97·8% nitrogen and 2·2% oxygen.

Tests with Canaries.—The results of tests with canaries are given in the table following. Three canaries, designated as *A*, *B*, and *C*, were used in the experiments:—

Test No.	Canary used.	Composition of Atmosphere.					
		At beginning of experiment.			At end of experiment.		
		Oxygen.	Nitrogen.	Carbon dioxide.	Oxygen.	Nitrogen.	Carbon dioxide.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	B.	9·42	90·48	0·10	8·50	90·90	0·60
2	C.	9·25	90·65	·10	...	...	...
3	A.	7·65	92·25	·10	7·55	92·05	·40
4	C.	7·83	92·07	·10	...	...	...
5	A. & C.	7·10	92·80	·10	...	...	...

Test 1.—The canary, *B*, showed immediate distress, as evinced by rapid breathing, open bill, and unsteadiness. In 10 minutes' time the bird was apparently in normal condition, except for a slight increase in the rate of breathing. It was removed from the atmosphere at the end of 1 hour.

Test 2.—The behaviour of the canary, *C*, was similar to that of the bird in the previous experiment.

Test 3.—The canary, *A*, showed immediate distress by panting and unsteadiness, but did not collapse or evince more distress than the bird in trial 1. It was left in the atmosphere for 1 hour.

Test 4.—The canary, *C*, collapsed as soon as it was placed in the atmosphere. It breathed very slowly with eyes and bills closed, but recovered its normal state in less than a minute after it was removed to fresh air.

Test 5.—One canary, *A*, showed distress, but did not collapse in 20 minutes. Another canary, *C*, was placed in the atmosphere and immediately collapsed.

Tests with Mice.—Some experiments were also made with white mice, similar to those made with the canaries. The results were as follows :—

Test No.	Composition of Atmosphere.					
	At beginning of experiment.			At end of experiment.		
	Oxygen.	Nitrogen.	Carbon dioxide.	Oxygen.	Nitrogen.	Carbon dioxide.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
1	7·07	92·83	0·10	7·75	92·05	0·20
2	6·89	93·01	·10	7·12	92·78	·10
3	6·70	93·00	·30	...	...	...
4	5·90	94·00	·10	...	...	...

Test 1.—The mouse showed symptoms of distress immediately. At times it appeared normal and again appeared sluggish, but did not collapse. It was left in the atmosphere for 1 hour.

Tests 2, 3.—The results were the same as test 1.

Test 4.—The mouse showed immediate distress and collapsed in 6 minutes. One minute after removal from the atmosphere it was on its feet.

Comments on Results of Tests. Canaries show some distress in atmospheres containing 9·4% oxygen, more pronounced distress in atmospheres containing as low as 7·6% or 7·8%, and in an atmosphere containing as little as 7·1% oxygen may or may not collapse. Mice are slightly more resistive to atmospheres low in oxygen. In about 7% oxygen they show some distress and become more or less sluggish. One mouse resisted for 6 minutes an atmosphere containing as little as 5·9% oxygen before it collapsed.

Effect on Men.—For comparison with the results given above some observations made by the authors and others on the effects on man of atmospheres low in oxygen are included here. A member of the Bureau of Mines breathed air in and out of a bag having a capacity of about 70 litres. By means of a can of caustic potash inserted between the man's mouth and the bag, the exhaled carbon dioxide was removed. Under these conditions, of course, the oxygen content of the air in the bag was gradually reduced, and when it had fallen to about 7% the subject lost consciousness for a few seconds. The mode of action of the "oxygen want" is instructive. Although the man felt warning symptoms of collapse, but did not appreciate that he was in serious danger of losing consciousness; in fact, he wanted to continue, and just before he collapsed made a show of resistance against discontinuing the experiment. He felt no real distress until some time after the experiment, but on the next day he was decidedly unwell.

Effect of a Mine Atmosphere Low in Oxygen.—In its insidious action "oxygen want" acts as carbon monoxide frequently does; that is, when the oxygen is slowly decreased. One difficulty in comparing the mode of action of the two lies in the scarcity of experimental data on the effects on men of atmospheres containing small percentages of oxygen.

Comparison of Effects.—From the foregoing experiments on birds and mice and on men, it will be seen that oxygen deprivation causes collapse in men in about the same time it does in mice and canaries. The animals may collapse in atmospheres of different composition and presumably the same is true of men. The fact is evident that birds and mice cannot be used safely as indicators of atmospheres low in oxygen by exploring parties in mines.

Canaries are chiefly valuable for indicating the presence of carbon monoxide, to which they are much more susceptible than man. After-damp may contain enough oxygen (about 17%) to support the flame of an oil-fed lamp so that exploring parties entering it may have no means, other than canaries, of detecting that dangerous gas, carbon monoxide. When oil lamps go out, an exploring party unequipped with breathing apparatus may advance into an atmosphere dangerously low in oxygen, even though the party be carrying canaries.

An acetylene lamp does not go out until the oxygen in the atmosphere decreases to about 13%. In such an atmosphere a party is in no immediate danger, although close at hand there may be atmospheres considerably lower in oxygen, so that by advancing a short distance the members of the party may endanger their lives. However, when canaries are used in mines, that is, after a disaster, exploring parties are invariably equipped with oil safety-lamps and electric lamps, so that the danger from using acetylne lamps need hardly be considered here.

The results of these experiments may be summarised as follows :—

Atmospheres that are deficient in oxygen begin to affect men when the percentage of oxygen is about as low as that affecting canaries and mice. Canaries are slightly more susceptible to "oxygen want" than are mice. In mixtures of air and nitrogen containing about 7·6% to 7·8% oxygen, canaries show pronounced distress. When the oxygen content is about 7% mice show considerable distress, and a man is in grave danger of dying; hence canaries and mice should not be used by exploring parties in mines to show when men unequipped with breathing helmets should retreat, because the atmosphere is low in oxygen.

Mice and canaries, especially the latter, are chiefly of value for indicating to exploring parties the presence of dangerous proportions of carbon monoxide. In an atmosphere in which oil-fed lamps will not burn, an exploring party should not depend upon canaries for further guidance, but should use breathing apparatus in advancing into the atmosphere."—GEORGE A. BURRELL and G. G. OBERFELL.—Science and Art of Mining, Dec. 16, 1916, p. 227. (E. M. W.)

SECURITY OF TENURE ON TRANSVAAL MINES.—"The many advantages of security of tenure are fairly obvious and include, as the principal benefits, the following :—

The man who has been working for some time on the mine and has reasonable expectation of retaining his job is less likely to stay away from work, to work indifferently, to disobey instructions or to neglect precautions required for the elimination of accidents and prevention of phthisis.

From the employee's point of view, security of tenure is of great value, in that he is able to settle down in a house, avoid the expense of constant removal, can live reasonably near his work, make friends and companions, and is thus enabled to enjoy sport and recreation encouraged by the Company.

There is also the advantage, from the native point of view, of boys working constantly under the same white man, and returning to the same mine to that white man.

An important incentive to keep underground men from constant moving would be a really satisfactory scheme of annual holiday.

This is one of the most difficult questions to deal with, as several alternatives are possible.

In order to put the matter clearly, it seems advisable to state, firstly, the reasons why holiday leave for miners is advisable, and, secondly, the conditions which it would be desirable to ensure in granting this leave.

Firstly—Desirability of Granting Holiday Leave.—Apart from personal experience which has proved the necessity of a break in one's work of at least three to four weeks per year in order to ensure continuous good health, it is known that the holiday also increases one's efficiency and prevents many casual absences from work through colds and other slight ailments.

It is obvious that these reasons apply to underground employees more than to others, as they work under less favourable conditions.

The Association is therefore of the opinion that a compulsory holiday scheme is an essential for the efficiency and health of the miners, and will, even if apparently costly, actually prove an economy to the mines.

Secondly—The Conditions which it would be Advisable to Ensure in Granting this Leave.—These are as follows :—

1. That a man does not work underground on another mine during his holiday, as otherwise the money expended would not fulfil the purpose for which it was designed. In order to ensure this, a miner should not receive his discharge papers from the mine until the end of his holiday.

2. That he should not remain on the Witwatersrand, where he is likely to meet other men who are at work, and will naturally continue the habits to which he is accustomed, with the result that he will get no real change.

3. That for this purpose he should as far as possible be afforded facilities, by arrangement with the Railway Administration, which would enable parties to travel at excursion rates at any period of the year. At the same time, the miner should be given sufficient money to enable him to pay for the holiday.

In view of the above, it is recommended :—

1. That every underground employee be given two weeks' leave per annum after working twelve months on one mine, three weeks per annum after the second, and four weeks after the third and each subsequent year. The period of service for calculating this leave to date from the 8th July, 1913, or from date of adoption of this recommendation.

Note.—The desirability of defining a year's service is a matter for consideration if the recommendations are accepted.

2. That he be given 15s. for each working day falling within the period of leave which he is granted under the preceding clause, six working days being reckoned to the week.

3. That employees shall take their leave at times convenient to the Company, but at the same time the Manager shall arrange that so far as possible leave be granted when due. In the event of it being necessary for an employee to postpone his leave to suit the convenience of the Company, he shall not suffer in so far as the principle of leave being granted every twelve months is concerned.

4. That leave be not cumulative, and that the foregoing leave regulations, if adopted, take the place of all leave regulations at present in force and be universally followed and adhered to.

A clause would, of course, be inserted in all agreements that these privileges are given to men at the time and under conditions convenient to the mines, and that they are in the form of a gratuity and not a right which can be demanded by the men."—Appendices to Reports on Time and Labour Saving on the Mines.—Association of Mine Managers of the Transvaal, June 25th, 1915.

PAYMENT OF WAGES ON TRANSVAAL MINES.—"On the subject of the payment of wages, the Sub-Committee has no uniform recommendation to make. It would seem that there are numerous systems, all worthy of consideration, by which the incentive to the employee to do good work is obtained and by which an excessive payment to the employee is avoided.

Since the study of this matter was first commenced by the Sub-Committee it is gratifying to record that the recommendation of the Association, which dates back for some years, viz., that the flat contract should be abolished, has received general approval, and finally is being universally adopted.

In the payment of miners, the following principles merit attention and may tend to improve the standard of work and insure the contentment of the wage earner :—

A reasonable proportion of the miner's total earnings must be on a day's pay basis.

A definite and separate allowance should be made for long service.

The scheme of payment must be simple, and must remove evil of extreme fluctuations in wages.

The scheme must be acceptable to the Government, the mines, and the men.

The system must be such that necessity for employer to alter rates is reduced to a minimum.

Separate consideration should be given for working under unfavourable conditions.

The possibility of a miner increasing his earnings by efficient work should be in proportion to the savings resulting to the Company in respect of each item.

Another point which merits attention is that a greater general contentment may be obtained by the adoption of a uniform wage or day's pay system.

While some discontent would arise by the adoption of the principle, it is thought by those who advocate it that only a minority of miners will be affected, and that any falling off in efficiency could be met by improved supervision." Appendices to Reports on Time and Labour Saving on the Mines. —Association of Mine Managers of the Transvaal, March, 1916. (G. H. Sm.)

MISCELLANEOUS.

Prophylactic Inoculation against Pneumococcal Infection.—The following are the conclusions arrived at by Dr. F. S. Lister in his paper entitled "An Experimental Study on Prophylactic Inoculation against Pneumococcal Infection in the Rabbit and in Man." published by the South African Institute for Medical Research in October, 1916:

Conclusions.—1. More than 60% of the cases of Lobar Pneumonia amongst natives on the Rand are associated with but two, though not always the same two, groups of Pneumococcus. Group 'A' is constantly the most prevalent, the second position is occupied sometimes by Group 'B,' at others by Group 'C.'

2. There are at least four groups of Pneumococcus on the Rand which are additional to those recognised by Dochez and Gillespie in America.

3. Immunilogical reactions associated with these various groups are specific for each group.

4. Normal rabbit or normal human serum is incapable of agglutinating virulent Pneumococci derived from cases of Lobar Pneumonia, even under the most favourable test conditions.

5. Agglutinins and opsonins are readily produced and easily demonstrated in the blood of rabbits and men subsequent to inoculation with suitable doses of killed Pneumococci.

6. The method employed by Sir Almroth Wright in his opsonic technique, provided that the volumes of serum are varied, is sufficiently practical and accurate for following the progress of pneumococcal immunisation.

7. Very much smaller doses of killed Pneumococci will elicit the formation of agglutinins and opsonins, both in rabbit and man, when the inoculum is injected into a vein than when subcutaneous inoculation is employed.

8. Killed pneumococcal vaccines have very slight toxicity; subcutaneous inoculation of forty thousand million cocci usually causes little reaction in either the guinea-pig, rabbit, or man. Intravenous inoculation of twenty thousand million cocci in the rabbit, and forty thousand million cocci in man, have given rise to but very slight reactions.

9. Antibody-formation is greatly increased after a second inoculation and rises to a still higher degree after a third inoculation.

10. Rabbits inoculated three times with killed pneumococcal vaccine, in suitable doses, and having agglutinins and opsonins demonstrable in their sera, are resistant to at least eight times the lethal dose of living Pneumococcus (homologous group) when inoculated subcutaneously.

11. Agglutinins and opsonins are intimately concerned in the mechanism of resistance against pneumococcal infections.

12. Pneumococcal vaccines prepared from glucose-serum-broth cultures are less satisfactory antigens in the rabbit than in man.

13. Pneumococci that have sedimented in a 40-hour old glucose-serum-broth culture are devoid of antigenic properties both for rabbit and man.

14. For prophylactic purposes in man the subcutaneous method should be adopted. Three inoculations, at seven days' interval, should be employed; each dose should consist of 6,000 (six thousand) million cocci of each group against which immunity is desired.

15. Three intravenous inoculations of pneumococcal vaccine have been given in each of seven cases of Lobar Pneumonia during the acute stage. The treatment has not given rise to any clinically recognisable negative phase; all the patients recovered and were found to have elaborated antibodies to the strains which comprised the vaccine." —F. S. Lister, M.R.C.S., L.R.C.P. (G. H. Sm.)

Abstracts of Patent Applications.

(C.) 34/17. John Graeme Balsillie. Process for obtaining water from aqueous particles in elevated regions of the atmosphere. 3.2.17.

This application refers to obtaining water from the atmosphere by electrical means.

(C.) 14/16. Charles Hansen. Improvements in water supplying attachments for rock-drills. 16.2.16.

This application refers to a water supply through hollow drill steel for hammer drills, the water being supplied, not through the piston of the drill, but through the anvil block, which has a packing ring to prevent the water from being forced backward into the air cylinder. The patent also describes various modifications and means for the application of the principle.

Changes of Address.

Adams, A. E., *to* "Highfields," Wellington, Salop, England.

Allen, H. E., *l/o* Cleveland; Luipaardsvlei Estate & G.M. Co., Ltd., P.O. Box 53, Krugersdorp.

Drucker, A. E., *l/o* London; 1502, Pacific Street, Brooklyn, New York, U.S.A.

Forrest, B. C., *l/o* Johannesburg; Durban-Roodepoort Deep, Ltd., P.O. Box 110, Roodepoort.

Galbreath, N. M., *l/o* Benoni; Rooms 13 and 14, Caledonian Mansions, Johannesburg.

Hay, Errol, *l/o* Knights; West Rand Consolidated Mines, Ltd., P.O. Box 38, Krugersdorp.

Hyman, L. H., *l/o* Johannesburg; S.A. Oil and Fat Industries, Jacobs, Durban, Natal.

Mills, E. W., *l/o* Korea; c/o American Legation, Pekin, China.

Robinson, V. E., *to* Globe & Phoenix G.M. Co., Ltd., Que Que, Rhodesia.

Womble, L. A., *l/o* Springs; Witwatersrand Deep, Ltd., P.O. Box 5, Knights.

APR 1 5 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVII. JUNE 1917. No. 12.

Proceedings AT Annual General Meeting, June 23, 1917.

The Twenty-first Annual General Meeting of the Society was held in the South African School of Mines Building, Johannesburg, on Saturday, the 23rd June, 1917, Prof. J. A. Wilkinson (President) in the chair. There were also present:—

29 Members: Messrs. J. Gray, G. Hildick-Smith, H. A. White, James Littlejohn, H. R. Adam, J. Chilton, H. S. Meyer, C. Toombs, F. Wartenweiler, F. W. Watson, John Watson, E. M. Weston, W. R. Dowling, J. E. Thomas (Members of Council), R. W. Bennett, J. M. Dixon, C. J. Gray, H. C. Hilton, A. King, P. T. Morrisby, S. Newton, E. A. Osterloh, H. W. Pursglove, C. Rowe, Dr. A. W. Rogers, J. J. R. Smythe, J. A. Taylor, A. Thomas and T. P. Waites.

6 Associates and Students: Messrs. O. A. Gerber, E. G. Harding, H. L. Krause, N. F. Lovasz, W. Waters and L. A. Womble.

10 Visitors, and Fred Rowland (Secretary).

The minutes of the meeting held on the 19th May, 1917, as recorded in the May *Journal*, were confirmed.

The President: The next item on the agenda is the Annual Report of the Council and the Financial Statement for the past year, which I will ask the Secretary to read.

ANNUAL REPORT OF COUNCIL.

Your Council has much pleasure in submitting its report on the work of the year.

This is the 21st Annual Meeting of the Society, although it came of age really in 1915. The South African war, however, prevented Annual Meetings being held in 1900 and 1901, and accounts for the fact that, although established in 1894, we are to-day holding our 21st Annual Meeting. The Society in common with other similar bodies is feeling the effects of the present world war, and a great many of our members and associates are doing their share in the conflict. In consequence, our activities have of necessity been confined to a more limited sphere. In the circumstances we venture to think we can congratulate ourselves that we are able to continue our work at all, especially when even the British Association is unable to hold its Annual Meeting this year, the first break in the continuity for 86 years. Your Council trusts, that when it is necessary to present its next Annual Report to you, a most welcome peace will prevail throughout the world. The need for the introduction of new industries and expansion of old industries in South Africa has been brought home forcibly to us, and measures have been and are being taken, to encourage such developments. If this is done thoroughly, there is every prospect that this Society, in common with other scientific and technical societies, will find ample scope for its activities for many years to come.

Accounts.—The accounts for the year show that your Finance Committee has kept in mind the views expressed in last year's report, and exercised much care in the management of the finances of the Society. Despite the fact that the revenue shows a decrease, which was more or less anticipated, of about £130, the expenditure, which has been kept to the lowest possible limit, was further reduced compared with last year, by £200, and as a result the year's working shows a surplus of revenue over expenditure of £187 7s. 11d. Much of this is due to reduced expenditure on the *Journal*, which, despite an increase in the cost of printing (to meet which a slight reduction was made in the number of pages printed) shows a total cost to the Society of just under £48 for the year. For this we are indebted to the continued and increased support given to the advertisement columns. Turning to the Balance Sheet, the fixed deposits remain practically the same, but the cash on current account is increased by over £125, and is more than sufficient to meet all our liabilities. The subscriptions outstanding for the current year only, amount to £181 12s. 0d. As stated last year, the Council has decided not to remove any members from the Roll until after the war when, with the return of members from active service, the subscriptions of those in arrear for two years and over will receive careful consideration. This amount stands at £994 17s. 6d. By the advice of our Hon. Auditors the outstandings are not taken into our accounts as an asset, owing to the difficulty of putting down any figure, which is likely to be recoverable. For a period such as we are passing through now the accounts, as a whole, may be considered satisfactory.

Membership.—During the year 17 Members have been elected and 6 Associates and 5 Students admitted. 22 Members and 10 Associates have resigned, while 4 Members and 5 Associates have died or been killed in action: Lieuts. T. H. Clesham, W. Nicklin, G. Simpson, Jr., and Mr. J. H. Stevens, Messrs. A. Gifford, C. J. v. Loon, H. J. Laidler, and Major W. H. Pickburn and Lieut. A. R. Flynn (Associates); leaving the total membership to date as 756, a decrease of 17 since the last report. This is a matter of regret, but in the circumstances it is difficult to see how a better result could have been achieved. Your Council anticipated that it would have received more assistance from the membership in this matter, as well as in the attendance at the monthly meetings, but in this respect it has to record its great disappointment.

Journal.—The *Journal* has been issued every month during the past year, and although economy has had to be practised and the number of abstracts published much reduced, your Council is of opinion that contributions submitted at our meetings have been up to the standard of past years. The following is the list of papers

	June 1895	June 1896	June, 1897.	June, 1898.	June, 1899.	June, 1902.	June, 1903.	June, 1904.	June, 1905.	June, 1906.	June, 1907.	June, 1908.	June, 1909	June, 1910.	June, 1911.	June, 1912.	June, 1913.	June, 1914.	June, 1915.	June, 1916.	June, 1917.
Hon. Members	5	5	5	8	14	9	13	18	18	16	17	18	21	22	20	23	25	25	26	26	25
Life Members		1	1	1	1	1	1	2	3	4	7	7	8	9	9	9	10	10	10	9	9
Members	49	81	101	197	281	291	441	639	680	680	683	618	630	731	711	733	618	550	481	463	454
Associates	—	—		180	238	243	281	338	321	314	342	357	342	402	380	442	396	351	287	272	263
Students	—	—		—	—	—		4	8	4	7	18	20	60	57	22	21	15	2	3	5
	54	87	107	386	534	544	736	1,001	1,030	1,018	1,056	1,018	1,021	1,224	1,177	1,229	1,070	951	806	773	756

(INCORPORATED MAY, 1907.)

REVENUE ACCOUNT for the year ended 31st May, 1917.

Dr. Cr.

1915-16. £ s. d.	EXPENDITURE.	1916-17. £ s. d.	£ s. d.
(78 14 5	To CHARGES (including Postages, Bank Charges, Insurance, etc.) ...	65 10 11	
60 13 4	,, PRINTING AND STATIONERY ..	65 15 9	
11 19 4	,, RENT, LIGHTING AND TELEPHONE...	10 4 3	
596 0 0	,, SALARIES	596 0 0	
20 0 0)	,, DEPRECIATION ON FURNITURE .	5 0 0	
	,, Excursion, Loss on ...	5 13 6	
767 7 1			748 4 5
(25 0 0	,, GRANTS:--*Seymour Memorial Library* Prizes: School of Mines	7 7 0	
8 8 0)	Witwatersrand University Committee	21 0 0	
33 8 0			28 7 0
	,, SOCIETY'S JOURNAL—		
(548 19 3	Cost of Reporting, Printing, etc.	505 5 8	
-325 4 3)	*less* Received for Subs. and Advts. after deducting commissions on Advts. and Collections ..	457 11 7	
223 15 0			47 14 1
116 18 1	,, BALANCE, Surplus on year's working		187 7 11
£1,141 8 2			£1,011 13 5

1915-16. £ s. d.	REVENUE.	1916-17. £ s. d.	£ s. d.
	By SUBSCRIPTIONS—		
(636 6 0	Members, current year ...	601 13 0	
117 12 0	do. arrears collected ...	95 11 0	
268 10 9	Associates, current year ...	222 12 0	
74 0 6	do. arrears collected ...	41 2 0	
1 11 6)	Students	3 3 0	
			967 1 0
1,098 0 9			
12 12 0	,, ENTRANCE FEES . .		8 8 0
18 11 5	,, INTEREST ON FIXED DEPOSITS		18 13 2
12 4 0	,, SALES OF TRANSACTIONS.. .		17 11 3
£1,141 8 2			£1,011 13 5

BALANCE SHEET, as at 31st May, 1917.

Dr. Cr.

1915-16 £ s. d.	LIABILITIES.	1916-17. £ s. d.	£ s. d
131 17 5	To SUNDRY CREDITORS	119 2 3	
22 1 0	,, SUBSCRIPTIONS paid in advance	22 11 6	
39 19 0)	MINING EXHIBITION FUND	39 19 0	
			181 12 9
193 17 5			
	,, REVENUE AND EXPENDITURE ACCOUNT—		
(377 9 9	Balance at June 1, 1916 ...	494 7 10	
116 18 1)	*Add* surplus as per Revenue and Expenditure Account, May 31st, 1917	187 7 11	
			681 15 9
494 7 10			
£688 5 3			£863 8 6

1915-16. £ s. d.	ASSETS.	1916-17. £ s. d.	£ s. d.
	By CASH AT STANDARD BANK—		
(118 7 3	Johannesburg	223 5 7	
9 5 6	London	26 12 8	
1 0 1)	,, On Hand, Johannesburg ...	4 11 4	
128 12 10			254 9 7
(405 13 4	,, Cash on Fixed Deposit with accrued Interest	405 13 4	
54 12 1)	,, Cash in Post Office Savings Bank with accrued interest ...	56 5 3	
460 5 5			461 18 7
50 0 0	,, OFFICE FURNITURE		45 0 0
49 7 0	,, SUNDRY DEBTORS		102 0 4
£688 5 3			£863 8 6

We have examined the above Balance Sheet and accompanying Revenue and Expenditure Account with the books and vouchers of the Society, and have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the affairs of the Society, according to the best of our information and the explanations given to us, and as shewn by the Books of the Society.

Sgd. ALEX. AIKEN and CARTER, } *Hon. Auditors*

JOHANNESBURG, 23rd JULY, 1917.

(Signed) JAMES LITTLEJOHN, *Hon. Treasurer*

(Signed) FRED. ROWLAND, *Secretary*, *Fellow Chartered Inst. Secretaries.*

and notes submitted or published during the year:—

July, 1916.—"The Valuation of Mines," by Prof. R. A. Lehfeldt.
August, 1916.—"The Manganese Silver Problem," by Mr. Walter Neal.
September, 1916.—"Presidential Address on Recent Advances in Chemical Industry," by Prof. J. A. Wilkinson (President).
October, 1916.—"Shaking Chute for Flat Stopes," by Mr. S. Nettleton. (Note.)
  "The Hardening and Annealing of Metals," by Prof. T. Turner.
  "Testing the Strength of Explosives," by Mr. J. A. Campbell.
November, 1916.—"Ear Defenders," by Mr. A. J. Herald. (Note.)
  "Industrial Research," by the President. (Note.)
  "Neutralization Effect of Ash on Acid-Sand in Stope Filling," by Mr. Chris. Toombs.
  "Flotation Concentration Experiments on a Transvaal Gold Ore," by Mr. F. Wartenweiler.
  "Ore Treatment at the Falcon Mine (Rhodesia)," by Mr. H. R. Adam.
December, 1916.—"Removal of Rust from Iron Plates," by Mr. F. W. Watson. (Contribution.)
January, 1917.—"Comparison of Stamp Milling Costs between Californian and Nissen Stamps at Modder "B," by Mr. K. L. Graham. (Contribution.)
February, 1917.—"The Solubility of Lime," by Mr. Andrew F. Crosse. (Note.)
  "A New Track and Rail Joint," by Mr. L. W. Macer. (Note.)
  "Comparison of Stamp Milling Costs," by Mr. H. A. White. (Note.)
  "New Applications of Thymolphthalein and Naphtholphthalein, including Rapid Methods for Analysing Limestone and Ammonium Salts," by Dr. James Moir.
March, 1917. "Silicosis in Rats in a Witwatersrand Mine," by Dr. J. Pratt Johnson.
April, 1917.—"Sugar for Dust Filters," by Mr. R. A. Cooper. (Note.)
  "Notes on Treatment of Pilgrims Rest Ore," by Mr. R. Lindsay.
  "Comparison of Stamp Milling Costs," by Mr. K. L. Graham. (Contribution.)
May, 1917.—The Natal Coalfields—Phases in Development," by Mr. W. Taylor Heslop.
  "Assayers' Certificates" (new Government Regulations).
June, 1917.—"First-Aid in Mines," by Mr. T. P. Waites. (Note.)
  "The Construction and Maintenance of Slime Dams," by Messrs. J. E. Thomas and E. A. Osterloh.
  "Notes on Explosions of Fire Damp and Occurrences of Gob Fires in Natal," by Messrs. J. E. Vaughan and F. A. Steart.

Awards and Grants.—The usual grant of prizes to Evening Class Students at the S.A. School of Mines and Technology was continued during the current year, and the Council is pleased to offer the same inducements in the coming year.

The Society's interest in the desire to extend the facilities for higher education on the Rand was shown by a donation of 20 guineas being made to the Witwatersrand University Committee's funds.

Visits.—During the year two visits were made, one, in conjunction with the S.A. Institution of Engineers, to the works of the Pretoria Portland Cement Co., Ltd., at Pretoria, and one to Chandler's Brewery, Ophirton. Both were highly appreciated by the members who attended, and much interest was evinced in the work being done to promote industries in South Africa.

Roll of Honour.—It is still difficult to obtain a full list of those members and associates who have gone on active service. We have been advised of several who have returned from Overseas and East Africa, and resumed their occupations. During the year notification has been received of the deaths in the field of the following, and to their relatives we would convey our sincere condolences:—Lieuts. T. H. Clesham, W. Nicklin, and G. Simpson, Jr. (Members), and Major W. H. Pickburn and Lieut. A. R. Flynn (Associates).

Since the last report we have received advice that the following are, or have been, on active service:—Capt. D. Gilchrist, Lieut. J. V. Harris, J. F. McPadden, H. B. Williamson, W. J. Lakeland, H. A. N. Bluett, E. H. Croghan, Messrs. L. A. Gross, D. Ordman, B. C. Forrest, L. A. Wright, C. Y. Bruce, H. F. Donkin, L. Marks, G. Nicol, G. Skuthorp, R. Winters, T. K. Prentice, J. M. Dixon, D. J. Arkell, C. F. G. Farrell, F. R. Atkinson.

The following promotions have been notified:—Capt. F. J. Trump to be Lieut.-Col., (and D.S.O.); Capt. P. N. Nissen to be Major; Sergt.-Instructor L. A. E. Swinney to be Lieutenant.

South African Red Cross Society.—Your Society's interest in the work of this Society continues to be shown by the fact, that your Secretary is still permitted to act as its Hon. Secretary, and free accommodation is provided in its offices for the work. As one of the integral branches of Red Cross South Africa, the officially recognised body for all Red Cross work in South Africa during the war, a great amount of good work for our sick and wounded soldiers is being done, and many expressions of gratitude for the help afforded to the many Hospitals and Ambulances within the Union, in East, Central and South-West Africa, as well as Overseas, have been and are being continually received. A great amount of labour and time, as may be imagined, has been spent in this work, but it has been carried on with as little interference as possible with the work of our Society.

The Annual Ambulance Competitions for the Shields presented by our Society for Mine Surface and Underground Workers, were held as usual in April, and after being won for some years by teams from the Crown Mines, the Village Deep ambulance teams carried off both Shields after a particularly strenuous competition. As a result of more stringent Mining Regulations with regard to ambulance matters, greater interest is being taken in first-aid work by employees. With the increased efficiency demanded by the examiners, it is hoped that when a larger proportion of the employees have a real knowledge of first-aid, the sufferings of those who are unfortunately injured during their daily work, will be greatly decreased. We again regret that no entries were received for the Colliery Shield.

Industrial Activities.—Scrap steel is being melted at the electric furnace established at the Robinson Mine, and shoes and dies are being cast which compare favourably with those imported. This furnace was started by the Chamber of Mines on the initiative of your Council's sub-committee on Industries Development, with the co-operation of the South African Institute of Electrical Engineers and the South African Institution of Engineers. Most of the preliminary difficulties have now been overcome, and the main question now is greater capacity.

The local production of assay litharge may also be anticipated shortly .

The Government Munitions and Industries Committee mentioned in the last Annual Report, has practically ceased to exist, and an Industries Advisory Board has been appointed by the Government, of which Prof. G. H. Stanley, one of our Past-Presidents, is a member. A Scientific and Technical Committee has been appointed to act in conjunction with the Board. Dr. Caldecott and Mr. L. Colquhoun, members of the Society, represent metallurgy and chemistry respectively on this Committee.

It is hoped to appoint also a Director of Technical Research, when with active and generous support from the Government for the work of the Board and Committee, a great development of the many resources of this country may be expected.

General Items.—With regard to the joint housing scheme for the various local Societies, active steps are now being taken to forward this matter, and the Council hopes soon to be in a position to place a tangible scheme before you.

The developments regarding the University, have appeared from time to time in the local press. The institution of a University in Johannesburg will be of great benefit to the scientific development of the country and the Witwatersrand in particular.

Owing to prevailing conditions it has not been possible to consider the question of holding the Fourth Mining Exhibition, but as soon as affairs become normal, the matter will receive full consideration.

During the year 9 meetings of the Council have been held, as well as the necessary meetings of the Editorial and Finance Committees. The attendance at the Council meetings, which averaged 14 per meeting, have been as follows:—

J. A. Wilkinson	9	F. W. Watson...	7
J. Gray ...	8	J. Watson ...	9
G. Hildick Smith	8	E. M. Weston...	7
H. A. White ...	6	A. Whitby ...	5
H. R. Adam ...	7	J. Littlejohn ...	4
J. Chilton ...	8	A. F. Crosse ...	1
K. L. Graham...	4	J. R. Williams...	2
F. G. Macdonald	9	A. McA. Johnston	1
H. S. Meyer ...	6	W. R. Dowling	2
C. Toombs ...	5	G. H. Stanley...	9
F. Wartenweiler	2	J. E. Thomas...	7

The Council has been deprived of the services of Mr. Lawrie during the year, owing to his severe illness. It is sincerely hoped he will soon be restored to health and strength.

Your thanks are due to the Corresponding Members of Council, and to the members of the various Committees of the Council for much valued work in the interests of the Society.

The Society is again indebted to the local Press for reports of its proceedings, and also to Messrs. Aiken and Carter, Hon. Auditors, for the painstaking care with which the audit of our books is carried out.

The Secretary: With reference to the Accounts, I am submitting to you a statement to-night which has not been audited. As some of you know, I have been indisposed for some time, and so the Finance Committee suggest that they now be accepted, subject to audit.

The President: I beg formally to move the adoption of the Annual Report, and the Financial Statement—subject, of course, to the audit by the Honorary Auditors of the Society.

Mr. E. M. Weston *(Member of Council):* I beg to second the motion. I think, considering the war, the statement is most satisfactory.

The President: If there is no discussion on this Report, I assume that silence gives consent. I do not think there is anything to criticize in the Report, but I think we ought to congratulate ourselves on having an Honorary Treasurer who has husbanded the resources of this Society so well during a very trying year, and who will hand on to the incoming President and Council a satisfactory financial basis for the forthcoming year.

The President: The next item is the declaration of the election of Officers and Council for the ensuing year.

SCRUTINEERS' REPORT AND DECLARATION OF ELECTION OF OFFICERS AND COUNCIL.

The Secretary: It will be necessary for you to confirm the election of scrutineers. The matter was overlooked at the last meeting, in May, and the Council appointed Messrs. Morrisby, Newton, Osterloh, and Thomas to act as scrutineers, subject to your approval.

The action of the Council was confirmed, after which the Scrutineers' Report on the ballot for the election of officers was read as follows:—

Johannesburg,
23rd June, 1917.

The Chairman,
Annual General Meeting of Members.

Dear Sir,

We have to report that we have this day examined 81 ballot papers, handed to us by the Secretary.

Our Scrutiny enables us to declare the result of the ballot, as follows:—

President.
Mr. G. Hildick Smith (unopposed).

Vice-Presidents.
Mr. H. A. White.
Mr. A. Whitby.
Mr. H. S. Meyer.

Hon. Treasurer.
Mr. J. Littlejohn (unopposed).

Members of Council.
Mr. J. Gray.
Mr. K. L. Graham.
Mr. F. W. Watson.
Mr. John Watson.
Mr. H. R. Adam.
Mr. C. Toombs.
Mr. C. E. Hutton.
Mr. F. Wartenweiler.
Mr. J. Chilton.
Mr. E. M. Weston.
Mr. H. C. Hilton.
Mr. F. G. Macdonald.

Yours faithfully,
(Sgd.) P. T. Morrisby.
,, S. Newton.
,, E. A. Osterloh.

The President: I think that that list of names speaks for itself, and I am sure the Society can look forward to a very successful time in the incoming year.

I have very much pleasure in congratulating Mr. Hildick-Smith on being elected to be President of this Society, and I sincerely hope he will have a successful year of office. With the gentlemen whom you have elected to support him, I think he may confidently look forward to that. I also congratulate Mr. White, Mr. Whitby, and Mr. Meyer on being elected as Vice-Presidents, which proves that you have held to your practice of electing representatives of the three fields of activity your Society covers. All these gentlemen have done good work for the Society in the past, and I think that is a very good augury that they will continue to do so in the future. As far as your Council is concerned, most of these gentlemen have already served the Society for some years, and I am sure the Society has again to be congratulated on its choice. You have elected two new mining members, Mr. Hutton and Mr. Hilton, who, I feel sure, will prove an accession of strength to the Society. With a Mining President, a Mining Vice-President, and several Mining members of Council, mining will probably loom a little larger in the Society than it has done for some years past.

Mr. G. Hildick-Smith *(President):* I have to thank you very much indeed for the honour you have done me in electing me as your President for the coming year. Unfortunately, I think, for the Society, I happened to be the odd man in, either of the other two members, who were nominated for the position of President, is more worthy of it than I am; I feel I am quite unworthy of the position you have given me, but I shall try my best to follow the excellent example set by the Presidents in the past. In order to do this, I must have your help, and I therefore ask the members—especially the Vice-Presidents and Members of Council—to support me during my term of office, and to forgive any mistakes I may make. If we all pull together in the coming year, we shall, I am sure, have as successful year as the times will permit. I again thank you very much indeed for the honour you have done me, and I hope we may pull altogether for the good of the Society.

Mr. H. A. White *(Vice-President):* In the name of the Vice-Presidents I thank you for the honour you have conferred upon us in electing us to this position, and to assure you that in the future we shall do as we have done in the past, namely, our best for the benefit of the Society. In saying that, I should also like to couple with it a vote of thanks to the scrutineers for the arduous work they have again performed gratuitously, as they have done for several years.

Mr. Jas. Gray *(Member of Council):* It is my pleasing duty to thank you, on behalf of Members of Council, for our election. At the same time, I would like to second the vote of thanks to the scrutineers, proposed by Mr. White.

Mr. S. Newton *(Member):* On behalf of the scrutineers I would very much like to thank you for the very kind remarks you have made. There were only 81 papers this time; but we are looking forward to the time when we again shall have 200 or 300 ballot papers to scrutinize, as that means so much more interest is being taken in the work of the Society.

ELECTION OF NEW MEMBERS.

Messrs. C. Toombs and J. Watson were appointed scrutineers, and after their scrutiny of the ballot papers the following members were declared elected :—

Butlin, C. L., Modder "B" G.M., Ltd., P.O. Box 14, Brakpan. Mine Manager.

Friedman, Percy, New Goch G.M., Ltd., P.O. 1096, Johannesburg. Mine Surveyor.

The following Student had been admitted :

Lovasz, N. F., S.A. School of Mines and Technology, Johannesburg.

General Business.

FIRST-AID ON THE MINES.

Mr. T. P. Waites *(Member):* About the middle of May of this year an accident befell a native in the mine where I work. This native was cleaning out a winze, when the skip, getting out of control, quickly went to the bottom of the winze. The native's left eye was badly injured, the back of his skull was fractured, his left leg, below the knee, was broken to pieces, the leg was almost cut off, joined to the rest of the limb by a strip of flesh only.

Happening about seven in the morning, the native had been carried to the station before I reached it, at half past eight. He had been subjected to first-aid by a man who had attended but three lectures on first-aid, and he, to his credit be it said, gave what help he could in accordance with the slight training he had received. Beside this one man, who did something to assist the injured, there were nine others on or near the station, but not one of these had given help, and neither held the Red Cross Certificate in first-aid nor its equivalent. As they said: "We were afraid of doing *any* thing, lest we should do the *wrong* thing. *One* idea of "Safety First"!!

It was not a case of callousness, it was a case of pure funk, coupled with a lack of training in what was needful. Nor was it a matter of the victim being only "a nigger." The same fate would have befallen a white man, had such been the victim instead of a native. It was an instance of men, all of them of average intelligence, some of good education, whose intelligence had not been drawn out, educated — laboriously extracted — in first-aid work, nor had they received the usual "cramming" in Red Cross first-aid methods, which the mines so freely give, but which is not so freely taken up by the major portion of the men on the mines.

How the victim of this mishap was hauled out of the winze, carried thence through a stope and along the drive to the station, I know not, nor did I ask any questions about it, but that he must have had a rough time, goes without saying. Fortunately the blows to the head had made him senseless.

I am not holding up to scorn these men, who "passed by on the other side." I am merely giving this example of what may happen at any time to any one of us, in a mine, or out of it. Accidents will happen, but that so many men in a mine at one place should be quite useless when an accident happens, is a crime.

Being convinced, and holding strongly to this conviction, perhaps I may have a tendency to express my views strongly—so much depends on the point of view—that compulsion is needed to have *all* men trained to such a degree that their aid would be of use in case of accidents, I entreat this Society, and the Red Cross Society, to urge on those who have control over the mines, the necessity for instituting compulsion in this without delay, also the Mine Managers' Association and the Chamber of Mines. Therefore I suggest that all at present engaged in mine work should be obliged to obtain the Red Cross Certificate in first-aid, within, say, twelve months; and that all who may present themselves for blasting certificates should not be granted these unless they hold the Red Cross Certificate in first-aid. Employers demand some proof of efficiency in handling explosives, tools, plant and machines: some idea of what hanging-wall is, or foot-wall in steep stopes. Employers should also be capable of looking after the care of the human beings placed under their charge.

It is cases such as I have brought to your notice that make the matter of first-aid, the need for it, the value for it, the benefit of it, strike home, and if it strikes you as it has struck me, I feel that we, as individuals and as a Society, can do something in trying to make compulsory the acquirement of knowledge of first-aid by all who work in our mines. Further, I appeal to you individually and as a Society to do so.

I have been waiting for nearly 12 months for an example like this, to show you the necessity for compulsion with regard to first-aid among miners. I was preaching it in season and out of season last year; it was not acceptable to some: but I hope it will receive the episcopal and apostolic attention of even the medical profession this time! In addition to the example I have given you, I had another only yesterday. A miner on my section came up and said, "Something has happened down near my box. I do not quite know what has happened. It was practically an explosion; there was a rumbling in the dead-end where my explosives box is kept." I dare say you will know that you cannot get the truth out of a miner, even with cyanide solution! I went along, and found that his box had caught fire. The outside was charred, but the inside showed hardly any signs of burning; but the drive was acrid and pungent with nitrous fumes. I said, "Did you go into those fumes to see what had happened?" He said, "No." Anyway he was sent to hospital for treatment for gassing, although he said he had not been into the fumes. That is another case where a man who has received a blasting certificate and did not know the danger incurred in running into nitrous fumes.

Mr. G. Hildick Smith *(President Elect)*: It may be of interest to you to know of my recent experience on the Bantjes Consolidated Mines with regard to first-aid classes. We have been, for some time past, having meetings of a Safety and Sanitation Committee, at which all sections of the officials and men are represented; I was asked by the representatives of the men on that Committee to arrange first-aid classes—we had not long finished one, as it so happened. In arranging the classes I was pleased to find that about 40 names had been sent in of men, who wished to attend first-aid lectures. In the past it was necessary to endeavour to persuade men that they really should have some knowledge of first-aid. This greater keenness on first-aid work may, I think, be due to the influence of the local Safety First Movement, aided by the paper called *The Reef*. As to underground workmen, on some mines men with first-aid certificates are paid a bonus, I think, for being in charge of a small section of the mine for first-aid purposes in case of accidents. It would help, I think, if this idea became general.

The President: The idea Mr. Waites has put forward, that all underground employees should have a first-aid certificate is by no means new to me, as it has been discussed again and again at the Red Cross Society's Council meetings. Many difficulties arose, although I think it has been in everyone's mind there, that it would be the very best thing possible. I believe one of the chief difficulties put forward is that the underground population is still a floating one, and there is no doubt that first-aid work is encouraged on some mines, whereas on others it has never been heard of, in spite of the many attempts of the Red Cross Society to bring it prominently forward. Again, first-aid work is like every other work, and must be kept up by good practice after classes are over, otherwise, when an accident occurs, those who are hurt are not able to have the assistance they should get. It is a well known fact on some mines here that ambulance work is extremely well organised, and in these cases the workers are like an army of soldiers going into the field with a fully equipped ambulance service; and this ought to be the rule so that miners might go to work every day knowing perfectly well they have got an ambulance service, which will attend to them in moments when they need it.

I agree with Mr. Waites when he says he he would like to see every underground mine employee in possession of a first-aid certificate, but the difficulties are great and, so far, the Council of the Red Cross Society has not been able to overcome them. However, I think things are a little better now than they were a few years ago, and I only hope that in time we shall be able to solve all these problems, as we have solved a few of them already. I have every sympathy with Mr. Waites. I think it is fearful that a man, be he black or white, or any other colour, should have to suffer as this particular man suffered, and I think I am speaking for everybody when I say there is not one of us here who would like to feel we might have to suffer in this particular manner because there was nobody there to help us, and when men, knowing that they could not help us, passed us by on the other side rather than fear to do the wrong thing.

PROPOSED CHANGE OF MEETING NIGHT.

Mr. Jas. Littlejohn *(Hon. Treasurer):* The question has cropped up as to whether it would be more convenient for the majority of members to change the Saturday night to any other night of the week for our meetings. Personally, Saturday night is a very inconvenient one for myself, and I should be only too glad if any other night were arranged. I beg to move that a plebiscite of the whole Society be taken, in view of the fact that for the last few months the meetings have been so poorly attended that scarcely a quorum has been present.

Mr. J. E. Thomas *(Past-President):* Shall we confine it to either a Wednesday or a Saturday.

Mr. Jas. Littlejohn: I would agree to that, and if you will kindly allow me, Mr. President, to alter my motion, I beg to propose that a plebiscite be taken as to whether Wednesday or Saturday night be adopted as the night for the ordinary meetings of the Society, either on a three or even a six months' trial.

Mr. H. S. Meyer *(Member of Council):* I beg to second the motion.

The President: I think this is a very important matter indeed, and I should like to have the views of some of the members present, especially those living along the Reef.

Mr. H. A. White: I should like to say for my side of the Reef, that Saturday night is the only night we can get back by train.

Mr. E. M. Weston *(Member of Council):* I think, as regards members living out along the West Rand, that Saturday is the day on which they could come to the meetings far better than any other day.

Mr. H. S. Meyer *(Vice-President):* Of course, that is the reason why it has been Saturday right from the start of the history of this Society, simply to suit the members who live outside. I do not know whether the train services are any better now than they were in those days, or relatively not, and you will probably get a vote from all the members that Saturday night should be retained. But there is no harm done in trying to settle the thing one way or the other.

Mr. H. A. White: I think, in that connection I should mention a suggestion that I have frequently made before this Society, and that is that the position of the moon should be considered. People who have to get about on the mines are still largely unprovided with good roads, and the risks on many of the mines to this day are great. If the position of the moon were considered and we arranged that our meetings should take place on bright moonlight nights, we might get a better attendance than at present.

The President: Would you like to move an amendment?

Mr. H. A. White: I would like to move an amendment that the opportunity should be given of voting as to whether a moonlight night should be selected for the meetings.

The President: The amendment, I understand, is not that moonlight nights should be chosen, but, if the motion is passed, then a proviso should be made that preference should be given to moonlight nights.

Mr. G. Hildick-Smith *(President Elect):* There are two things we should take into consideration. The Wednesday night, if anybody is coming from along the Reef to do shopping, is rather unsuitable; the shops are all shut on Wednesday afternoon and people might like to come in earlier, and it might suit them better to come on a day when the shops are open. There is another point, that there are members who belong to other technical societies as well as this, and one would rather have to arrange meetings so that they do not clash. Then, again, there is the possibility of a closer working scheme between several societies, and I do not know how that is likely to be affected by the Saturday night.

Mr. W. R. Dowling *(Past-President):* I beg to second the amendment.

Mr. Jas. Littlejohn: I do not wish to press this motion. I only wished to bring it before you because there has been a very poor attendance of members at the meetings of the Society for the past few months. If there is any other suitable night, I think it ought to be discovered and adopted. I should like to get a night that will suit the convenience of most members.

Mr. G. Hildick-Smith: Will Mr. White add that providing the moonlight night is not a night that clashes with the other societies?

Mr. W. R. Dowling: I do not think that our real trouble is the night, whether it is moonlight or not. Although I seconded the amendment, I think the real trouble is lack of interest amongst members. I do not think there is any doubt that Saturday night suits the mining members. I have been a member for 20 years, and it was always considered that Saturday night was best.

Mr. H. S. Meyer: My opinion is that the real trouble is due to the excellence of the *Journal*. As long as you get that, it does not matter whether you come to the meetings or not, and I think a large number of members look upon it in that light, because they know they will receive a report of the proceedings, in due course, without attendance at the meetings.

The President: If there is no further discussion, I will put the motion, with the amendment incorporated.

Mr. Jas. Gray *(Member of Council):* How will that affect the issue of the *Journal*?

The President: That is contingent on whether this motion is passed or not, and will have to be considered later.

On being put to the meeting, the motion was declared lost.

GOLD IN PEBBLES.

The Secretary: You will remember that at the last meeting I read a letter from the Acting Manager of the Eldorado Banket Company regarding gold in pebbles. I sent this pebble to Dr. Mellor, and he has written me a note, which I will read to you.

Dr. E. T. Mellor (contributed): Many thanks for giving me an opportunity of examining the pebble from the Eldorado mine. Being unacquainted with that locality I am not able to institute any comparison between the conglomerate there and the Rand banket. I understand, however, that the two are very dissimilar, and this appears to be borne out by the character of the specimen sent to you, which is quite unlike anything I have met with on the Rand. The "pebble" from which the specimen was taken must have been much more in the nature of a boulder than a pebble in the ordinary sense of the term.

THE CONSTRUCTION AND MAINTENANCE OF SLIME DAMS.

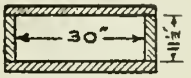
Jas. E. Thomas (Past-President) and E. A. Osterloh (Member).

Some little time ago the President suggested that a paper on the construction and maintenance of slime dams would probably be of interest to many members of the Society. The authors have accordingly undertaken to present their views on the subject in the hope that discussion will be forthcoming which will place on record ways and means of avoiding, or combating, the numerous troubles that beset those responsible for their security and upkeep.

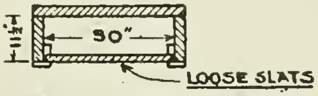
There is no doubt that, if it were possible from financial and other considerations, the construction obtaining for water reservoirs would give the greatest security, viz., that retaining walls should be built of dry material to the ultimate height required, before putting the dam into commission, such walls being of the usual trapezoidal section, with the base proportionate to the load it has to withstand. As slime dams have, however, in the majority of cases to be built from the slime itself, the most that can be done is to endeavour to make the outside walls of suitable thickness from the heavier slime particles, avoiding any excess of moisture in their construction.

How this may be accomplished to a certain extent the authors will try to explain. The site selected for the dam having been surveyed, a trench should be dug at least 3ft. wide and 1ft. 6in. deep on the line which the toe of the outside walls is to follow. The object of this trench is to serve as a preliminary channel along which to conduct the slime pulp and also, in some measure, to key the walls to the ground. The earth from the excavation should be thrown up on the outside side. The pulp from the slime residue discharge pipe should be led along the trench in one direction, *i.e.*, either to the right or left of the pipe, which should be at right angles to the line of the trench, until it will no longer flow. It should then be led in the opposite direction and the heavy, partly dried slime from the first used portion dug out with shovels and packed so as to form a channel at least

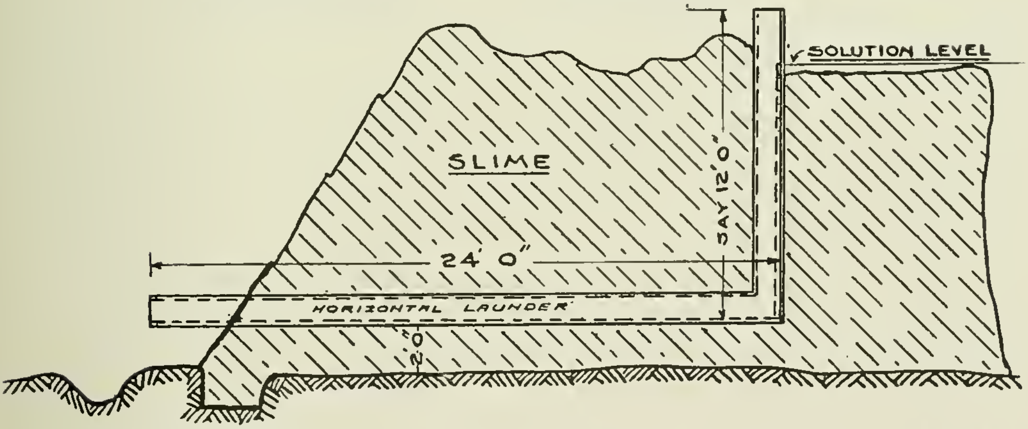
21 ft. wide, the lower outside edge of the wall thus formed coinciding with the outside line of the trench. This ensures that the outside walls of the dam will be composed of comparatively solid material, containing little, if any, excess of moisture, a result that cannot be obtained by dragging up wet pulp with scrapers to form the walls. An additional advantage in having just sufficient moisture in this material to render it plastic, is that any tendency for cracks to develop is almost eliminated. The operations described should be carried out on each portion of the trench alternately until the channels meet at the side of the dam furthest away from the inflow of pulp.



—SECTION OF—
—HORIZONTAL LAUNDER—



—SECTION OF—
—VERTICAL LAUNDER—



When the slime in the dam reaches a height of about 2 ft. above ground level, "L" shaped launders should be installed at suitable places, to drain off any excess of moisture from the surface of the dam. These launders should be made of 2 in. timber and have a section of approximately 2 ft. 6 in. × 11½ in. inside measurements, and arranged so that slats 2 in. thick × 1½ in. deep can be dropped into guides in the vertical portion facing towards the middle of the dam. The guides should be supported at intervals of 12 in. or so by horizontal struts nailed inside the launder. It is now possible to allow the pulp to flow from any part of the surrounding channels to the interior of the dam.

The following system of control has been found by the authors to give satisfactory results:—The pulp is allowed to flow along one channel to the side of the dam furthest away from the inflow, and is there led through the inside wall by means of short lengths of pipe to the interior of the dam. When the lower end of the channel becomes choked another opening is made nearer the inflow, and so on until the whole channel is full. The same procedure is then gone through with the other channel. Meanwhile the slime in the first channel is dug out and packed on to the existing walls. As the outside walls rise they are stepped back about 6 in. every 2 ft. in height and trimmed to form an angle of roughly 50° with the horizontal. The stepping renders any portion of the walls easily accessible for inspection and any necessary repairs. Trimming should be carried out by the ganger in charge of the natives working on the dam, and should be done so as to make the walls straight, any corners being well rounded off. This ensures that the walls will receive a thorough inspection and enables any tendency to bulge to be quickly detected, so that precautions can be taken to prevent the walls giving way. This may be effected by isolating the suspected portion of the wall from the rest of the dam, making a temporary channel further in, while repairs are carried out, by making a new channel altogether, some distance in from the one abandoned, or, in very bad cases, making a new wall by building up an outer wall from heavy slime outside of the original wall.

The regulation of the flow into the dam from the main channels should be so arranged that any superfluous water or solution remaining after discharging is finished, is kept well away from the walls and not allowed to remain too long at any one particular drainage launder.

In order to enable repairs to be effectively carried out, the authors recommend that two dams, adjoining one another for convenience in working, be used alternately and kept nearly at the same level. Then, if extensive repairs to one dam be required, no inconvenience will be experienced in disposing of the residue from the slime plant, and ample time may be given to making the repairs in a thorough manner by running the pulp to the other dam.

The solution or water from the drainage launders should be led to a special dam, adjoining the slime plant, from which it may be returned to the slime treatment circuit with a minimum expenditure on pipe and power lines. For this purpose a trench of heavy slime may be built outside and at the base of the main walls so that the solution will gravitate towards the slime plant. This trench, to some extent, acts as an anchor to the toe of the outside walls.

It will be evident that as the vertical portion of the drainage launders and the outside walls approach one another arrangements must be made to carry the launders more towards the middle of the dam. This may be done by attaching another "L" shaped launder to the top of the first, and so on as the level of the slime in the dam rises. The authors find that a length of 12 ft. is most convenient for the vertical launder, with 24 ft. for the horizontal portion. If the inside walls of the main channels are kept within a foot or so of the vertical launders, fitting of slats becomes an easy matter. It also enables close observation to be kept on the interior of the launder for any broken slats, etc. Should it become necessary to carry out repairs to the launders, within reasonable reach, they may be cut off from the rest of the dam by building a temporary wall of slime to prevent solution on the surface of the dam interfering with the work. If it should be considered that the carrying out of such repairs may not possibly remedy the defect it will generally be found cheaper to instal a new launder near the one to be abandoned, rather than waste time and labour on a doubtful job. To do this the main channel should be cut through at the level of the slime in the dam, the launder placed in position and the channel re-made over it. In such cases it will be necessary to extend the outlet of the launder down the side of the wall to the drainage trench. The old launder may be plugged from the outside and filled with heavy slime from the main channel.

When restarting a dam which has not been used for some time it will probably be found that holes have formed, causing leaks at most unexpected places in the outside walls. The authors have found it useless to try to stop such leaks from the outside but that it can be done from inside by allowing only heavy slime to pour into the hole, meanwhile working a shovel at the inlet to cause the sides to collapse and choke the hole lower down.

It has been noticed that walls built in the manner described show comparatively little erosion even after the heaviest rains. This is partly due to the fine sand in the heavy slime acting as a binder. Care must, however, be taken that the amount of sand present is not excessive or the walls will crumble away when dry. Slime carrying from 1·5% to 2% fine sand in the total charge yields a heavy portion suitable for making the outside walls.

In using the dams it is advisable to do as much as possible of the discharging from the slime plant in daylight. Should it be necessary to discharge at night the dam should be prepared the previous day so that the solution or water used in discharging will be kept away from the walls. In this connection it might be mentioned that a moisture ratio of 1 : 1 is sufficient when discharging slime pulp.

Two dams, with a total circumference of 6,000 yards to 7,000 yards, built in the manner described, will be found sufficient to receive the residue from a plant capable of treating up to 50,000 tons per month. The labour required to keep them in proper running order consists of an intelligent white man and from eight to ten able-bodied natives, according to the wetness of the season.

In putting these few remarks before you, the authors feel that they have merely touched the fringe of a subject that it is well worthy of the attention of those versed in problems connected with building dams of any sort in a scientific manner.

The thanks of the authors are due to the management of the Simmer Deep, Ltd., for permission to present their experience of slime dams on that property to the members of the Society.

Mr. H. A. White *(Vice-President)*: I should like to propose a hearty vote of thanks to Messrs. Thomas and Osterloh for their paper, which is breaking new ground, as I do not remember any discussion on the building of slime dams for years. It is a subject of great importance, as may be easily realized by those who have to travel along the Main Reef Road between here and Springs. They will find there a slime dam which possibly has not been built in the scientific manner described by Mr. Thomas, and during the discussion of this paper we hope to have some explanation of its collapse

I think that this subject of slime dams is part of a larger subject—that is with regard to the dumps of a mine. I think when a mine is first started the disposition of the dumps should be considered when the shaft is being sunk, and that the waste rock which is excavated in sinking that shaft should be the beginning of the dump. There should be only one dump for that mine; the basis of that dump might be the ashes from the boilers and the excavated rock in sinking the shaft. If they were laid out on a properly considered and scientific plan, say in rectangular walls, that, in time, would be the foundation of the sand dump, and in the centre of that would be the slime dam. It would be perfectly simple to calculate out the whole matter, so that one might know that that dump, once started, was going to last the whole of the life of the mine. In addition to putting there the sand and ash, the waste rock from sorting would also go there, and also spoil from excavations—in fact, the whole thing could be laid out in a thoroughly scientific manner, and instead of being eye-sores, as the dumps of the mines are at present, there is no reason why in the future these should not be planned to show a more pleasant aspect. They might have belts of trees planted round, and so on. That, of course, is, more or less, ideal, but the extension of the reef in the future will be principally in the East Rand, where the reefs are flat and there is plenty of ground available. Where they are steeper, as in the Central Rand, there is an excuse for mine dumps to be placed in any available spot.

I think that if on the far East Rand a metallurgist was called into consultation the moment they began to sink shafts, hundreds of pounds would be saved, and future generations would not have a permanent eye-sore.

The vote was then put and carried unanimously.

SOME NOTES ON EXPLOSIONS OF FIRE DAMP, AND OCCURRENCES OF GOB FIRES IN NATAL.

By Messrs. J. E. Vaughan (Member) and F. A Steart (Associate).

In bringing forward these notes, we do not intend to cover ground, which has already been covered again and again by leading mining engineers all over the world, but we wish to give some notes on past experiences in Natal, in the hope that they may be useful to members of this Society, and possibly to others.

Colliery explosions are much the same all the world over, and are undoubtedly one of the most harrowing of experiences. Apart from thinking of the persons entombed or killed outright underground, the rescuers are undoubtedly influenced by suffering and entreaties of the relatives of the missing men on the surface. Many valuable lives have been thrown away because the rescuers,—and all honour to them,—were influenced out of their better judgment by such appeals.

As the subject of colliery explosions is well understood, we do not propose to deal very fully with it, beyond recounting briefly some facts connected with explosions in Natal.

With gob-fires it is another matter. Some years ago, when the authors were confronted with numerous gob-fires, they consulted various text-books, but could find no reference of any value to such occurrences.

Explosions in Natal Collieries.—At many collieries in Natal, dolerite sheets occur between the seams and the surface, and the seams themselves are intersected by dolerite dikes. The consequence is that marsh gas, or in the vernacular, fire damp, is imprisoned in the coal. When a dike is cut there is usually an outburst of fire damp, which may continue in the form of blowers for weeks, months, or even years. Possibly some members do not realise the pressure and amount of gas which may be met with, but the two following examples, though, happily, not common, have come under the author's notice in recent years.

At the Durban Navigation Colliery four years ago a bore-hole was put down which encountered the coal at a depth of 800 ft. The gas issuing from the hole ignited at the fire of the drill boiler. An attempt was made to test the pressure of the gas; the gauge at once rose to its maximum (150 lb. to the square inch), and then the lining tubes commenced to rise from the hole. This hole is now a geyser, and every twenty minutes discharges a cloud of water 40 ft into the air. The probable pressure of the gas was at least 100 lb. to the square inch. At another mine, in a development heading, it was estimated that 1,200 cub. ft of marsh gas per minute was being given off from a face 15 ft. wide by 5 ft high. Added to the occurrences of gas, many of the Natal Mines are dry and consequently dusty, so that all the conditions for an explosion are to hand, and it only requires a little carelessness to cause a disaster.

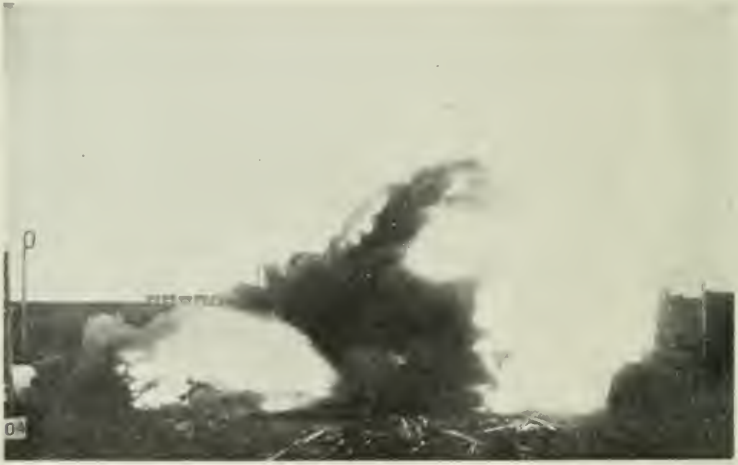


FIG. 1.

It has been stated that the dust in Natal Collieries is not explosive unless fire damp is present. We think that the photograph, Fig. 1, which was taken at the Altofts Testing Station in Great Britain, during a series of extensive experiments with Natal coal dust, disproves this argument. The flame extended 150 ft. from the mouth of the testing gallery, which is 800 ft. long.

History of Explosions in Natal.—Work in the Natal Coal Fields commenced on a small scale in 1889, and in that year 25,000 tons of coal were produced. The first record of an explosion of fire damp was in 1891, when a native was killed. From then onwards to 1897 no explosions occurred, although the numerous explosions of gunpowder underground in those days makes one wonder whether they were entirely due to gunpowder alone, or whether the firedamp had not ignited first and then the gunpowder. In 1897 four explosions occurred, resulting in three deaths and injuries to nine persons. From 1897 onwards to 1908 explosions were of frequent occurrence, the worst being that at Glencoe in 1908 in which seventy-seven persons were killed and nine injured, and that at Elandslaagte in 1901, when thirty-one were killed and fourteen injured. Altogether forty explosions have occurred in Natal, resulting in the deaths of one hundred and fifty persons and injuries to eighty-six others. We have little hesitation in saying that *all* of these would have been prevented had the present mining regulations been in force.

and what is more important, rigidly adhered to by all concerned. Many persons regard the mining regulations as being unnecessarily stringent, and look upon them as theoretical and impracticable, or, as has been said, framed to give Government officials soft billets. Whatever the regulations may or may not be, we think the following table (Figure 2) may be of interest. We would point out how after the explosions at Elandslaagte in 1901, the number of fatalities decreased in the years 1903-05, how another serious explosion occurred in 1906, that 1907 was a good year, and then the crowning disaster came in 1908. More stringent regulations were introduced in 1908, and we think the results justify the regulations.

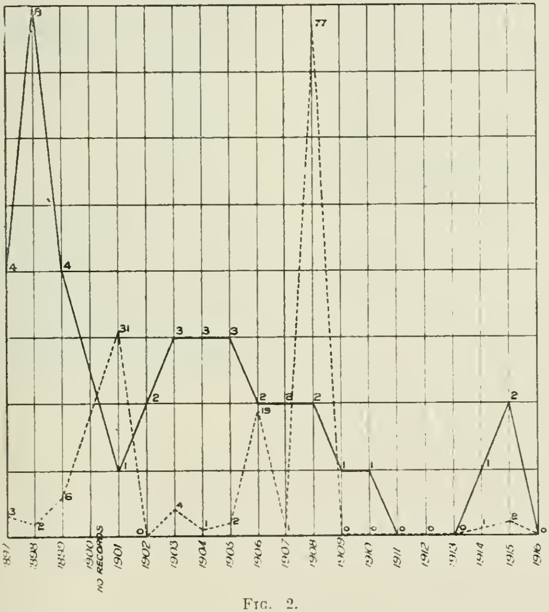


FIG. 2.

No. of Explosions per annum, thus:— ——4——

No. of Deaths per annum, due to explosions, thus:— - - - 8 - - -

The fatalities in 1914 and 1915 were due to sheer carelessness; in one case a miner opened his lamp to re-light it and thus caused the explosion. In the other a white miner in a non-fiery mine being given a lamp to test for gas in the early mornings, punched six holes in the gauze to save himself the trouble of cleaning it. One day he found gas!

Actual Explosions.—Colliery explosions in Natal have had no peculiarities as compared with explosions in other coal fields. They have been caused in the usual ways, such as:—

(1) Ignition of fire damp by a naked light or a defective lamp.
(2) Undue heating of lamp gauzes in an explosive atmosphere.
(3) Blown out shots.
(4) By underground fires.

In all the serious explosions there is no doubt that coal dust was the greatest factor in causing the destruction.

As illustrating the force attending these explosions the following may be of interest. Fig. 3 represents the Glencoe headgear at the Glencoe Colliery after the explosion in 1908.

The shaft is 360 ft. deep, and one cage, which was standing at the surface, was blown up into the headgear, and, as may be seen, wrecked one of the pulley wheels.

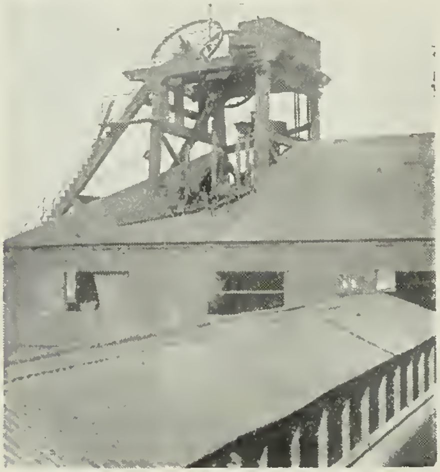


Fig. 3.

At the Cambrian Colliery in the same year, an even more violent explosion occurred, fortunately unattended by loss of life, as all persons had been withdrawn from the pit in anticipation of an explosion. An ignition of gas had occurred which started a fire, and eventually it became obvious that the fire could not be built off before an explosion occurred, hence everyone was withdrawn. The last party only reached the surface a few minutes before the first explosion, which was succeeded by others increasing in intensity, until five days afterwards the final explosion resulted. The shaft of the Cambrian Colliery is 700 ft. in depth, and rope guides are used. A truck of bricks weighing approximately three quarters of a ton was at the bottom of the shaft, the force of the explosion blew the truck and bricks up the shaft. (Fig. 4). The truck was projected into and remained embedded in the bottom of the cage on the surface, as may be seen.

We do not propose to describe any actual explosion in Natal, as full descriptions of the the most important have appeared in the Annual Reports of the Natal Mines Department. We do, however, wish to point out briefly what an explosion means to the mine concerned, and the possibility of preventing its occurrence. Apart from the dreadful loss of life (77 persons were killed) in the Glencoe disaster, work could not be resumed in the mine for several months after it occurred, and at the Cambrian Colliery the mine was not turning out coal for four months after the explosion. Apart from the cost of repairing the damage done in the mine, the loss in having a mine lying idle for months is very serious, as the labour complement must be kept on the mine, while nothing is being produced. This is not all. A mine in which a serious explosion has occurred is never the same again. The roof is shattered and needs continual re-timbering, the extra cost of pillar extraction is great, as falls have to be cleared up, and although it is impossible to say exactly what an explosion does cost, there is no doubt that for years afterwards mining costs are increased all round by causes due directly or indirectly to the explosion. Another very serious feature is that natives do not understand explosions. Many attribute such occurrences to *tagati* or witchcraft, and will not work on a mine which has had a bad explosion if they can go elsewhere. Explosions should not occur in a mine in which good discipline is maintained and the mining regulations strictly carried out.

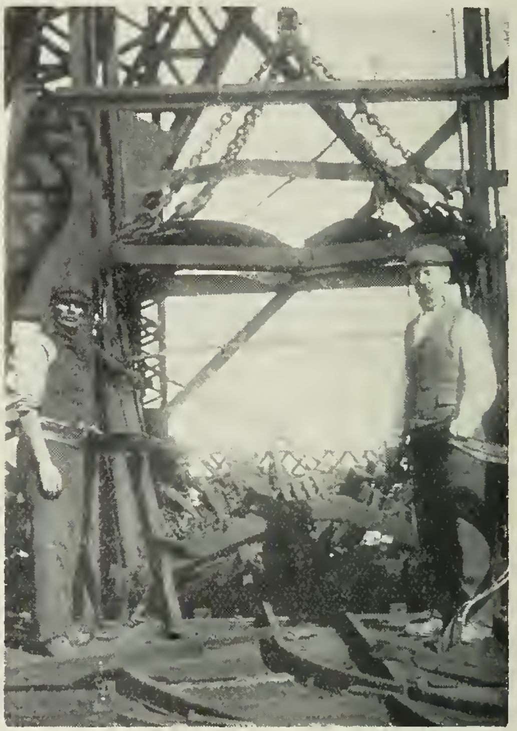


Fig. 4.

Anyone should be able to tell if there is 2% of gas in a place, and if boys are withdrawn when this occurs, and no blasting is done, there should be no explosion. Stone dusting and watering will also go far to minimise an explosion, if such remedies are *properly carried out*. Some persons grumble at the extra expense caused by stone-dusting and watering, but, when the cost of this is worked out it amounts to very little per ton output. A mine would be very well stone-dusted, that spent on stone-dusting a penny per ton of coal produced. After all, expenses incurred in taking precautions, are really only premiums for fire insurance. One explosion will cost far more than any precautions to avert it, and the loss of life and distress occasioned by a colliery explosion are such, that any means, no matter what the cost may be, should be taken to avert such a disaster.

It will be noticed that the number of explosions decreases in the year following a bad one for such occurrences, and this can only be put down to the disasters having impressed miners and officials, causing them to be more careful in the carrying out of the regulations. It is when a long time has occurred free from explosions that officials (amongst whom we include directors of mining companies) should re-double their efforts to guard against possible explosions. There should be no false sense of security and no "risking it." Reductions in cost do not usually lead to increased safety. It has often been said that the ignorant coloured employees are the chief source of danger in a fiery mine, but the authors have repeatedly found that the white miner is guilty of more acts contributary to an explosion than the coloured. As far as our records show, none of the explosions, which have so far occurred, have been due to coloured labour.

Gob-Fires.—In pillar and stall workings gob-fires are more difficult to deal with than in longwall workings; for the reason that in longwall workings the fire can often be dug out, which is not possible with the pillar and stall method—the one practised in Natal. A gob-fire is often a very difficult and treacherous thing to deal with, because no one cay say what is going on in the goaf, and an explosion may occur at any moment. The fire generates its own gas, and if air is getting into the goaf, it may be only a matter of time until an explosive mixture is produced. This mixture gradually diffuses towards the incandescent mass and an explosion occurs.

In the early part of 1912, a fire occurred at the No. 1 Pit of the Natal Navigation Colliery. Fire damp had not been observed in this pit for years, and the workings were wet. Whilst the fire was being built off an explosion occurred, fortunately unattended by loss of life, and the flame was seen by eye-witnesses to extend 400 feet from the goaf edge. Another very serious danger accompanying such fires is the almost invariable presence of carbon monoxide, which very often cannot be detected, except by its physical effects, and these, if not fatal, sometimes upset one's health for months. It can be said that carbon monoxide can be detected by carbon monoxide detectors, or better still by a mouse or small bird, but on one occasion in Natal an exploring party nearly lost their lives by relying on the chemical detector (palladous chloride), which did not re-act to the carbon monoxide. On another occasion a small bird was taken underground and remained unaffected when the exploring party were badly upset. The explanation for this was that the carbon monoxide was lying near the roof, and the bird was being carried near the floor, so that while the man was breathing carbon monoxide, the bird in the lower atmosphere was escaping. The authors have found that the only way to examine a fire area with comparative safety is to go with the fresh air and to retrace one's steps immediately any of the party feel increased palpitation of the heart or trembling in the knees.

In some cases where doubts have been expressed as to whether a gob-fire was developing, because there were no indications of carbon monoxide being present, analyses of air samples taken under the goaf edge have given valuable information. The following analyses illustrate this and were made with the Haldane apparatus in our office in Dundee, as soon as possible after the samples had been taken.

Analysis I.—

Oxygen	16·72%
Carbon dioxide	·86%
Methane	·17%
Nitrogen *(by difference)*	82·25%

With this low percentage of oxygen an ordinary light would not burn, not however, due to the amount of carbon dioxide present, but to the excess of nitrogen; and this is usually the case with all samples of 'black-damp' in Natal. Although no products of distillation are shown in the analysis, it is of importance as showing that oxidation of the coal is rapidly taking place. This analysis is typical of the first stage in the development of a gob-fire.

Analysis II.—

Oxygen	19·45%
Carbon dioxide	·4 %
Methane	1·65%
Hydrogen	·32%
Nitrogen *(by difference)*	78·17%

This shows a further stage in the progress of a fire, in which hydrogen is being evolved, but no carbon monoxide is detected by analysis.

Analysis III.—

This sample was taken by inserting the bottle right into the goaf.

Oxygen	12·58%
Carbon dioxide	3·78%
Carbon monoxide	2·44%
Methane	4·12%
Hydrogen	2·38%
Nitrogen *(by difference)*	74·70%

This shows the fire in an advanced stage of development, and also the necessity for having efficient ventilation. Naturally, no one could exist in an atmosphere of this description.

The first gob-fire in Natal occurred at the St. George's Colliery in 1908, and in the Mines Department Report for that year it was pointed out that, as a large percentage of coal in the future would be produced by pillar extraction, gob-fires should be anticipated and provided against as far as possible.

The Coal Seams.—In the Hatting Spruit District the two coal seams, known as the "top" and "bottom" seams respectively, are situated in close proximity to each other. The "top" seam varies in thickness from 2 ft. to 4 ft., and is overlain by a fairly thick bed of micaceous shale. The "bottom" seam averages about 5 ft. 6 in. in thickness and is separated from the "top" seam by 3 ft. to 6 ft. of sandstone and sandy micaceous shale. Both seams are generally of very good quality, and the calorific value is about the same. On account of the difficulties presented from a mining point of view by the seams being so close together and partly on account of the thinness of the "top" seam, up to a few years ago no serious attempt had been made to work the latter except at one colliery—St. George's—where a considerable amount of coal has been extracted from it.

In each case, where spontaneous combustion has taken place, it has been the "top" seam which has been the source of the trouble, and when the position of affairs is studied it is not surprising that this should be so.

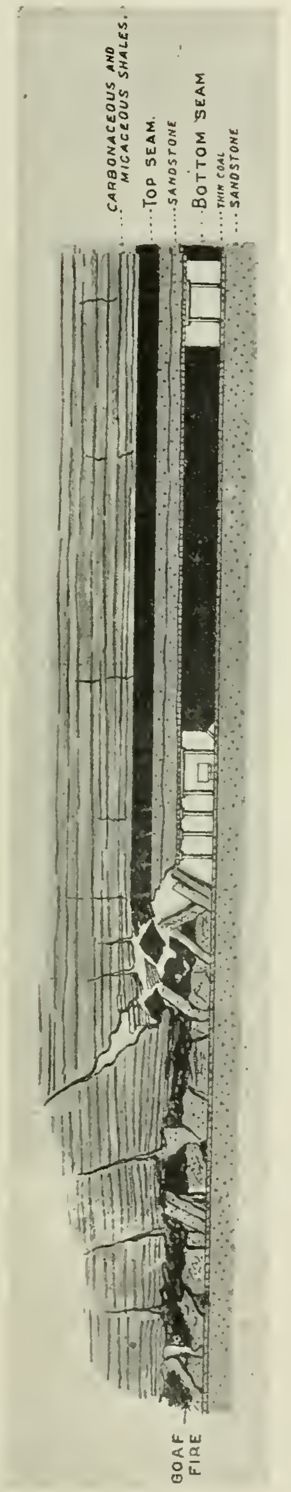
A reference to the section (see Fig. V.) will illustrate the position more clearly. It will be seen that as the pillars in the "bottom" seam are extracted and timbers are drawn, the "top" seam falls in large blocks into the goaf and is ultimately crushed and ground to powder by the falling roof, so that when once spontaneous combustion has been set up the fire is constantly being fed by fresh falls of coal from the "top" seam as the extraction of pillars proceeds in the "bottom" seam. Thus the conditions are almost ideal for keeping the fire alive.

Causes of Spontaneous Combustion.—Some colliery managers consider that the "top" seam is only liable to spontaneous combustion when, by the proximity of dikes or overlying or underlying igneous sheets, the coal has been rendered anthracitic, and the occurrence of gob-fires at the St. George's Colliery in localities where the "top" seam is said to be slightly anthracitic seems to support that view, although it is difficult to understand why the mere fact of the coal being of such a nature should cause it to be more liable to spontaneous heating than the more bituminous coal.

Although in many cases fires have started in semi-anthracitic areas, on most occasions they have broken out in bituminous coal, and the last fire, which occurred some six weeks ago, took place in an area which was twelve hundred feet from the nearest dike, and that a small one. The volatile constituents in the coal were 20%. In England, gob-fires are most prevalent in the bituminous coalfields, such as those of Yorkshire and the Midlands, and do not occur in the South Wales coal-fields, where anthracite and semi-bituminous seams are worked. We are inclined to think that the reason fires have occurred in semi-anthracitic areas in Natal is because pillar extraction has, as a rule, been started from a dike, or burnt coal. The heating up has been very gradual, but eventually a fire has broken out. Had the pillars been extracted in a bituminous section of the mine, the fire would probably have started just the same. As an instance of this slow heating,—at the Glencoe Colliery in January, 1912, a temperature in the goaf of 87° F. was noticed, with a little 'black-damp' accompanying it. The temperature at this same spot was carefully watched and rose slowly to 97° F. in May, 1913, when a fire broke out. In one case a fire occurred although the temperature at the goaf edge never rose above 75° F.

The cause of the spontaneous heating is probably due to the combination of mechanical and chemical action. The "top" seam, as already noted, is continually being crushed in the goaf by the falling roof and general subsidence. Oxidation is thus greatly facilitated and heat evolved. If sufficient moisture be present, further chemical action with resultant heat is probably produced, on account of the presence of sulphides. As the temperature rises the absorption of oxygen by the crushed coal becomes more rapid and 'black-damp' is given off in large quantities as a consequence, which in time makes its appearance at the goaf edge in the working places.

It is noteworthy, that in those Natal collieries in which spontaneous combustion has occurred, 'black-damp' has usually been observed in the vicinity of the goaf for some time before any considerable rise in temperature has been noticed. The appearance of 'black-damp' in pillar extraction workings should, therefore, be always regarded with suspicion as indicating that somewhere in the goaf oxidation is taking place at a rapid rate and that the first stage in the development of the gob-fire is proceeding. If the fallen roof is a good conductor of heat, the heat may be conducted away almost as fast as it is generated, in which case a fire will not take place. The roof of the "top" seam is often composed of micaceous and bituminous shale of a much lower conductivity than sandstone. Where this is so, the heat is probably not carried off as quickly as it is generated, the temperature continues to rise and the second stage is soon reached, when distillation of the coal commences. This stage is noticed at once by the peculiar smell which accompanies it, and which is chiefly due to the benzene vapour, which is being distilled off. The following analysis of gas, evolved from the coal of the St. George's Colliery, made by Dr. R. V. Wheeler, is of great interest as showing the gases which are given off from the distillation of the coal at 900° C.:—



Section showing how a Gob Fire is constantly being fed with coal from the top seam.

Benzene	2·00
Carbon dioxide ...	·70
Acetylene	·10
Ethylene	2·05
Carbon monoxide...	10·30
Hydrogen	62·05
Methane	19·40
Ethane	3·45
	100·00

When it is remembered that benzene is distilled off at a temperature in the neighbourhood of 600° C., it may be assumed that, when the smell of this substance can be detected there must be at least that temperature somewhere in the goaf.

The third stage is that of incandescence, which is usually accompanied by smoke, and the fire itself, if near the goaf edge, may then become visible. Where the seat of the fire is a considerable distance from the goaf edge, the various stages of development may succeed each other rapidly without any great increase of temperature being noticeable in the working faces. As soon as the benzene smell is detected, announcing that distillation has commenced, steps must at once be taken to isolate the affected area as far as possible, and prevent the products of distillation and combustion from reaching any working section of the mine, as the deadly carbon monoxide is also a product of a later stage of the combustion. Fresh air must also be excluded from the neighbourhood of the fire, because much of the gas distilled from the coal is inflammable. Where 'black-damp' is present the inflammable gases in the atmosphere at the goaf edge are often difficult to detect, as the "cap" on the flame of the safety lamp is partly obscured by the 'black-damp' present. By careful observation, however, a cap can generally be detected with a good lamp. Such an atmosphere, on account of the presence of the 'black-damp,' would be regarded by most miners as quite safe from the standpoint of inflammability, yet the mixture when diluted with fresh air may rapidly become explosive, and if the gob-fire has reached the incandescent stage the explosive mixture may find its way to the fire and become ignited. Hence the necessity of using every means for the prevention of access of fresh air to the seat of the fire.

Dealing with Outbreaks.—Two methods have been employed to deal with gob-fires in Natal.

1. By surrounding the affected area with substantial brick or stone stoppings so as to exclude access of fresh air, and afterwards leaving intact a double line of coal pillars to prevent any disturbance of the stoppings when pillar extraction has again commenced on the outside of the barrier.

2. The second method is that of extracting the coal as rapidly as possible from the pillars in the area in front of the outbreak and letting down the roof with the idea of excluding air from the fire by the fallen goaf. This method, however, may be said to involve some risk for the following reasons. In the first place because the goaf cannot be said to fall evenly or to close up completely on the extraction of pillars. It is therefore impossible by this means to be certain of excluding air from the fire. In the second place, if a section, in which this method is being used, is afterwards suspended or abandoned, the fire (which probably has never been extinguished) may work its way to the front by feeding on the fallen "top" seam and may still have to be reckoned with. For these reasons the method cannot be recommended and is now never employed.

The best method of dealing with spontaneous combustion in those districts of Natal where the upper and lower seams are so close as to render gob-fires probable, is for every colliery to anticipate such occurences and lay out the pillar working accordingly, *i.e.*, on the panel system. By this means each district is divided from the other by a solid barrier and is ventilated by a separate intake and return airway independent of any other district, so that a fire occurring in one district or panel would not affect any other district and, if necessary, the entrance to a district can, as a last resort be quickly sealed up. A system of panels can of course be more readily planned when a colliery is being newly opened out, but in the older collieries the system can be arranged to some extent by taking advantage of the natural dyke barriers which exist in every colliery, and by building strong brick stoppings in addition, so as to form artificial barriers in districts where pillars are about to be extracted.

Prevention.—In those districts in Natal where the "top" seam is situated a considerable distance above the "bottom" seam, spontaneous combustion is less likely to occur, but where the seams are situated as in the Hatting Spruit District, so long as the "top" seam is left and is being wasted in the goaf, gob-fires must be expected to occur from time to time. The best remedy for the evil in that district is, therefore, extraction of the " top " seam, wherever practicable.

The authors cannot too strongly urge upon managers and directors the necessity where a mine is not laid out in small panels, of building off areas in which pillars are being extracted into small panels, provided with doors, so that, should a fire break out, the doors can be closed at once and the area completely built off in a few hours. This may cost a little, but any pillar of coal saved is something, and much coal has been lost in the past which would have been saved had small panels been formed.

Conclusions.—We wish to conclude with a brief summary of some general notes, which are founded on actual and sometimes painful experiences in Natal:—

(1) Before pillar extraction is commenced the section should be converted into a panel or panels, and they should be as small as reasonably possible; one pillar of coal saved will pay for many stoppings.

(2) The " top " seam should be extracted wherever reasonably possible.

(3) Every effort should be made to leave as little timber and coal as possible in the goaf.

(4) Any rise in temperature above 70° should be looked on with suspicion. Thermometers should be placed at the goaf edges, and if any further increase in temperature occurs, steps for completely isolating the section in a few hours should be taken.

(5) As soon as the benzene smell can be detected, the section should be completely isolated.

(6) Stoppings should be of brick and cement, as it is impossible to get any other kind really air-tight. If the roof is broken or moving, the ground should be closely timbered up to the stoppings.

There has often been much controversy as to whether the building off operations should commence on the intake or return side. Generally speaking, we advocate building off the return side first, because if operations are commenced on the intake side, when the return side is reached the fumes are frequently so bad as to make the building off extremely difficult. If building can proceed from both sides at the same time, this is the best method to adopt, but no two fires are alike, therefore no hard and fast rule can be laid down, and each case must be considered on its own merits.

(7) A good travelling way should be provided round the stoppings, which should be examined daily; and two persons should go together in case foul air is met.

(8) Pillars should be extracted as rapidly as possible, and when the section is finished it should be built off at once, thus preventing the risk of a fire starting, and enabling the ventilation current to be diverted elsewhere.

(9) Loose coal should not be allowed to remain in old workings, as on two occasions in recent years fires have occurred from this cause.

These remarks and suggestions may seem obvious to many people, but much coal and many days of anxiety to mine officials would have been saved, had the methods thus briefly sketched out been adopted, when gob-fires first appeared in Natal.

In conclusion, it will be realised that once the fire gets beyond control the pit is lost for a long time, and great difficulty and expense will be incurred in recovering it. Take, for instance, a colliery (and there are several such in Natal) in which three or four fire areas exist and have been walled off. Should an explosion occur in such a pit, stoppings round the fires will be blown down, the fires will break out afresh, and in all probability the pit will be lost forever.

We cannot help thinking that the dangers of fires are not fully realised by some people. To deal with gas is a comparatively simple matter, but to cope with a fire which has got beyond the initial stages is perhaps the most dangerous and difficult operation in mining.

Mr. G. Hildick-Smith: I wish to propose a very hearty vote of thanks to Messrs. Vaughan and Steart for their most useful and interesting paper. It is a subject on which we do not often have papers here. This paper interests me especially, because I happen to have had quite a little experience in gob-fires, in the south part of the South Staffordshire coalfield, in what is known there as the " thick coal " seam, where, owing to the danger of gob-fires, the coal is worked in panels about 60 yards × 30 yards, surrounded by a rib of coal 10 yards wide. In opening a panel or " side of work "—to give it its local name—the most important point is to make provision for damming off the panel, in the event of a gob-fire occurring. This is done by cutting an annular space, about 4 ft. wide, round each roadway, where the roads pass through the 10 yard ribs. The depth of the annular cutting depends on the solidity of the coal; it must be sufficiently deep to be in coal free from fissures, in order that when the cutting is packed tightly with sand, the panel is hermetically sealed off from other workings. Before a panel is dammed off, "cogs" or "pigstyes" are built in the roadways on each side of the sand dams. In this method of working in the thick coal, about 30% of the coal is left in the mine in the form of pillars and ribs—as all the working is done homewards—but as Messrs. Vaughan and Steart suggest, it is better to lose that than a whole district and perhaps the whole mine.

Mr. C. J. Gray *(Member):* Fortunately I had very little experience of gob-fires in Natal. I left in 1910 and, up to then, the only gob-fire was that at St. George's Colliery, and that was not considered very serious; but gob-fires have since become an exceedingly serious matter. Many of the collieries had difficulty with fire-damp in my time, and that was quite serious enough, but since then with gob-fires as well, the troubles of managers and inspectors have enormously increased, and they can be congratulated that, in spite of those additional difficulties, they have secured a very great decrease in the accident rate and in explosions.

I noticed one or two slight oversights in the paper. on matters of which I have particular knowledge. Reference is made to more stringent regulations introduced in 1908—unless my memory is at fault, these were introduced early in 1910, after Union had been agreed upon. One of the last acts of the Natal Ministry was to issue a number of regulations intended to increase the safety of the collieries.

There is also mention of an explosion at Elandslaagte in 1901, when 31 were killed and 14 injured. That must refer to an explosion at the Campbell Colliery, between Hattingh Spruit and Glencoe. The worst explosion at Elandslaagte was one in which 18 deaths were caused. It is rather interesting that the papers in Natal reported only one death in that explosion. The reason was that those persons who were injured by the explosion did not die until a day or so after the accident.

I have much pleasure in seconding the motion.

The vote was then put and carried with acclamation.

ORE TREATMENT AT THE FALCON MINES, RHODESIA.

By H. R. Adam, B.Sc. *(Member of Council)*

(Printed in Journal, November, 1916.)

REPLY TO DISCUSSION.

Mr. H. R. Adam *(Member of Council):* This paper, being of a descriptive nature, naturally did not produce much discussion, but Mr. Woodburn's valuable contribution calls for a reply.

Regarding the recovery of copper as mill and flotation concentrate, the figures 0·20% and 0·70% respectively are the approximate results obtained in recent working, although Mr. Woodburn is correct in saying that 30% and 60% represents the result more nearly, according to the detailed figures given in the paper.

The present scheme of crushing to $\frac{1}{8}$ in. mesh was adopted after extensive trials as the best for gold recovery, due regard being paid to the suitability of the concentrate for sintering.

The proportion of flotation concentrate in the blast furnace charge was roughly about one-third of the total metal-bearing charge, but since the introduction of the new "cleaner" unit, the quantity of flotation concentrate produced has been reduced by about 25%, with a resulting decrease in smelting costs, which much more than balances the slight increase in the residue value.

Blast furnaces were installed at the Falcon Mine, since at the time the plant was designed there was not sufficient knowledge of large reverberatories available, and it was thought that the better known blast furnaces would prove more adaptable to local conditions.

With regard to the converters, the linings are composed of 25% clay and 75% siliceous material, the latter consisting chiefly of picked ore from the mine, but including also some customs ore. The 'life' of a lining is about four blows, producing about 16 tons of 'blister.' The question of using magnesite linings has been gone into, but these have not so far been adopted on account of the high cost of the material and difficulties due to the greater skill required in lining and blowing when this material is used.

Most of the customs ore sent in to the mine is too silicious for fluxing purposes, so that the use of the barren ironstone has to be continued. No regular supply of heavy sulphide ore, which might decrease fuel consumption, has up to now been procurable, although as development goes on in Rhodesia improvements in this respect may be looked for.

Mr. Woodburn's remarks on the possibilities of electrolytic refining in South Africa are of great interest, especially in view of the explanation by Mr. Brett that the Falcon Company was forced to sell their blister copper to New York for the recovery of the precious metals.

I was glad Mr. Woodburn had emphasised the great credit due to the Rhodesian company and the engineers and metallurgists concerned for the initiative they had shown at the Falcon Mine. This will be the better realised when it is known that the payments for freight to Umvuma were about one-third of the actual cost of the plant erected.

THE NATAL COALFIELDS—PHASES IN DEVELOPMENT.

By Wm. Taylor Heslop.

DISCUSSION.

Mr. Rowland Gascoyne (*Visitor*): Mr. Heslop's paper is a very interesting one, as it deals in a very convincing manner with the different phases of Natal coal mining, several of which are novel to coal mining in the other Provinces of South Africa.

I am particularly pleased to notice, that the author points out that the Ecca Shales were of an older geological age than the productive coal measures of Natal. Some of the members of the Society might say that the geological age of the productive coalfields of South Africa was of little technical importance so long as the seams of coal were profitable to work. It must not be overlooked, however, that many thousands of pounds had been, at different times, spent in the Cape and Natal owing to the delusion, that the geological age of the productive coalfields of South Africa was Ecca. There might have been some excuse for such geological views thirty or forty years ago, but to-day, when so much development has taken place in the coalfields of Natal and the Transvaal Province, the propagation of such ideas cannot be too strongly condemned. There might also have appeared some justification for the early Cape geologists to have based their geology on what was to be seen at Vereeniging, as that was the only and best known geological exposure of the productive coal measures of the Transvaal, but to-day the position is, and for the past twenty years has been, very different. Nevertheless we find that in Hatch and Corstorphine's "Geology of South Africa" the view is still advanced that the Transvaal and Natal coalfields are of Ecca age. I have opposed this view for the past twenty years, and I believe that every geologist of repute, including Dr. Hatch, now considers the productive coalfields of Natal and the Transvaal to be younger than the Ecca beds; the erroneous view to the opposite contained in the "Geology of South Africa" being entirely due to Dr. Corstorphine, who, to my knowledge, has never renounced that theory It may interest the mining members of this Society to hear that 14 years ago Dr. Corstorphine read a paper before the Geological Society of South Africa on the "Age of the Central South African Coalfields" in which he advanced the view that the productive coalfields of the Transvaal were of Ecca age. This view was adopted in the paper because the coal seam at Vereeniging occurred comparatively close to the Dwyka conglomerate, and a few feet above the coal seam there happened to occur another bed of conglomerate. Had, however, Dr. Corstorphine carefully examined the upper conglomerate no trace of its glacial origin would have been found. In the discussion which followed the reading of the paper I pointed out that the coal seam at Vereeniging did occur close above the Dwyka beds, but north and east the distance between the two gradually increase until in the Eastern Transvaal it became 200 ft. or more, and I expressed the opinion that when Dr. Corstorphine had been a little longer in the Transvaal he would probably change his opinion that the coalfields of the Transvaal were of Ecca age. That opinion has been changed, and the productive coalfields of Natal and the Transvaal were described in the "Geology of South Africa" as being of Ecca age, but even that upward move of the coal bearing beds is not sufficient, as will be shown by a careful examination of any of the productive coalfields of Natal and the Transvaal. It is very gratifying to find that despite the location of the productive coal measures of Natal and the Transvaal to the Ecca age by the authors of "Geology of South Africa," Mr Heslop places the coal measures in their proper position, and it is further to be hoped that in the future no foolish expenditure of capital in Natal and the Cape Province will be incurred looking for a profitable seam of coal in the Ecca beds, no matter how well developed and promising they may appear to be to those who go by appearances at one spot only.

The author's description of how fire damp difficulties increased with the depth of the coal seam is interesting, and those responsible for the safety of working the Natal collieries are to be congratulated upon the up-to-date methods adopted, even to "stone dusting" to reduce the risks of an explosion. In passing, it might be pointed out that if "coal dusting" was practised in the Rand gold mines, the miners' phthisis scourge might also be reduced, it having been shown that fine coal dust, when breathed, neutralizes the effect on the lungs to some extent of dust from quartzite rocks.

Similar sheets of dolerite to those described by the author also exist in the Eastern Transvaal coalfield, but as they occur about 200 ft. above the coal seam in huge escarpments, their intrusive character has not been established. When passed through in the shafts, can Mr. Heslop state whether the overlying as well as the underlying beds were also affected? In the Eastern Transvaal a small intrusive whin dyke was found to have damaged the coal seam for a width of over 200 ft. on either side. Several of the sheets also show the columnar structure described by the author, but as the coal mines in the Eastern Transvaal are shallow, only under specially favourable conditions for its retention has fire damp been observed.

The author goes somewhat extensively into detail with regard to the difficulties of working the two seams of coal with only a thickness of 2 ft. to 6 ft. of sandstone between them. One can imagine that whether worked by pillar and stall, double stall, or longwall, the task is not an easy one, as not only the intervening sandstone, but also the upper seam of coal varies in thickness—often to a considerable extent. There can be no doubt about the advantages of working such seams by the retreating system, whether by pillar and stall or longwall, in fact this would seem to be by far the best method to adopt, providing ample ventilation can be provided and sufficient patience exercised before the retreating begins. Perhaps to advance with a double stall and then retreat might be an advantage, but all will depend on the circumstances. If worked on the pillar and stall where the intervening sandstone is not too thick, the use of boreholes to indicate the position of the pillars might with advantage be resorted to. If worked by advancing longwall, and the roads constructed in the lower seam, any of the upper seam left behind would be sure to fire. If, on the other hand, the roads were constructed in the upper seam there is the risk of a serious outburst of gas from the lower seam every time a "weight" comes on. No matter from what aspect regarded, the retreating method has many advantages over the advancing system of working, not the least important being the reduction to a minimum of underground fire risks from spontaneous combustion. Perhaps the old-fashioned North Country system of stall working practised over a century ago would best hit off the conditions.

I am afraid Mr. Heslop gives more credit to the British royalty owner for preventing wasteful working than is his due. We have only to look at the scandalous amount of waste which went on in the early days when working thick seams of coal, to recognise how much was wasted. To-day most of the English coal-owners pay the British lessors so much per acre or per foot thick per acre worked, and this has more to do with the reduction of waste in working than anything else. With regard to working the top seam in Natal, it is absolutely necessary for safety against fires, and on that score alone there seems sufficient justification for the authorities to interfere.

With regard to goaf-fires there can be no question about the superiority of the retreating system of working, whether by pillar and stall or longwall, in fact under the conditions prevailing in Natal, advancing longwall would be exceedingly risky. Goaf fires can only be prevented by either an abundance of cool air or a total absence of ventilation in the goafs, and the latter is the easiest to obtain. Any method of working facilitating the leaving of roof coal or small pillars behind should be avoided. With ordinary care, owing to the fire stink given off, it ought to be impossible for a fire to assume dangerous dimensions without being first noticed. There are two leading systems of dealing with goaf fires, one by sealing it off, the other by filling it out. Where circumstances admit the last is to be preferred, sealing off in such cases being a last resource. In a fiery mine, the handling of a goaf fire is a delicate operation, the most suitable steps to take being dependent on surrounding conditions. I cannot agree with the author that seams of semi-bituminous coal are more liable to spontaneous combustion than purely bituminous coal seams. As a matter of fact, it is quite the other way about, for in a bituminous seam of coal it is always the most bituminous portion that starts the fire, whilst anthracite or semi-anthracite seams of coal rarely fire spontaneously. Probably the fires at St. George's in semi-bituminous coal described by the author were due to conditions which allowed of sufficient air to pass to start off spontaneous combustion and complete sealing off was probably impossible. It is often remarked that in fiery mines subject to spontaneous combustion, a heating of the goaf is not often accompanied by an accumulation of fire-damp, and the greater the heating the more difficult it seems to find gas in the immediate vicinity. Then, again, gas in a mine subject to spontaneous combustion does not seem to have the kick of fire-damp in a mine free from underground fires, and in case of an explosion, goes off with a thud, although the after-damp effects are often more serious. This makes the control of the ventilation, when dealing with a threatened outbreak of fire in a gassy mine, essential, and may sometimes require the reversion of the ventilation to prevent the carrying of an accumulation of gas in another part of the mine to the seat of fire. These risks make the filling out of a fire somewhat dangerous and the control of the ventilation essential, but as previously stated the method to be adopted to handle these goaf fires to the best advantage needs careful consideration, and under all circumstances promptness of action.

The President: Before closing this, the Twenty-first Annual Meeting of the Society, although the hour is late, I crave your indulgence for a few remarks.

The complete cessation of activity, which was necessitated during the period 1899-1902, has *de jure*, if not *de facto*, brought us to the end of the first epoch in the history of this Society. This meeting, therefore, forms the natural stepping stone to maturity, and I hope, that at such a time it will not appear irrelevant to look back upon what has been achieved, and forward to what we hope the Society will achieve in its future career.

Its formation dates back to the time when the stamp mill introduced from California reigned supreme as the only means of liberating the precious metal from its adamantine shell, and the mercury plate the sole time honoured device for releasing it from its age long captivity. During the years, which have elapsed, we have seen the stamp mill rise to a pitch of efficiency undreamt of then and still, though ofttimes challenged, proudly holding its own. The quest for auxiliary crushing machines led to the adoption of the flint mill, which had long been used for grinding cement to flour, and the combination of stamp and tube mills, as the latter have been renamed, is now standard practice as far as the Rand is concerned.

The many problems, which surrounded their employment for the comminution of the intensely hard banket, have been to a large extent successfully and at the same time economically solved, both in detail and construction; and in this work, as your proceedings prove, your members have had no small share. Almost coincident, however, with the birth of your Society was the origin of the use of solvents for the gold, which resisted the attraction of the mercurial plate even when stretched beyond the limits of true economy.

The stormy scenes, which heralded its infant years, were fertile in suggestions for many improvements, which culminated in the adaptation of the cyanide process to the slime, which, until then, had proved mere waste.

The chief characteristics of the post war period have been the further elucidation of these problems, and at the same time the solution of those intimately connected with the welfare and well being of the mine worker. The investigations in this field as recorded in the *Journal* bear unerring testimony to the great advances, which have been made in rendering the lot of the underground worker more in accord with the dictates of humanity. That much yet remains cannot be gainsaid, but Rome was not built in a day, and a complete solution is now merely a matter of time. Interspersed among the papers dealing with these main leading topics have been many, which have yielded much information upon the industries pursued in other parts of the country, and which have served to direct our attention to their successful existence.

One of the most noteworthy features of this period also has been the inauguration and establishment of all grades of education in this and the adjacent Provinces, and the activities in this direction show a progression, of which those, whose interest is of a casual kind, can but form little conception. The day and evening classes of the School of Mines are slowly but surely effecting great local changes, whose influence is being experienced, even at the present moment. The whole-hearted sympathy, which your Council has at all times given to the encouragement of this movement should augur well for the Society the future of which must be entrusted to the care of this generation.

The crisis in Europe, the cradle and fountain of our modern civilisation, still continues to afflict the world, and it is as yet too early to attempt to prophecy its message for the future. Of one thing, however, we can be quite sure, when it shall have ceased to be, namely, that the nation which adopts a policy of *laissez faire*, will soon find itself exposed to trouble from within as well as from without. The need for this country to arouse itself has been a constant theme during the past year, and it is hoped that the steps already taken by the Government may lead to action in the direction of increased scientific and industrial activity. In addition to this, signs of individual enterprise in many fields are not wanting. In these developments, most of which will doubtless be surrounded with problems which it is the function of your Society to consider and discuss, your horizon will be increased and you will find enlarged spheres of activity and usefulness. Democratic and catholic, as it is, in its membership and ideas, I have but little doubt that in the gradual evolution of this infant Union of South Africa your Society, under proper guidance and stimulated by the earnest support of its members, will play a part which will outshine even its own past records.

In vacating the chair, to which you did me the honour of election a year ago, I desire to record my sincere gratitude for the generous and ungrudging support I have at all times received from the Members of Council, and their officials. I have every confidence in handing over to the new President and his Council the affairs of the Society, because I feel they will be in safe hands, as most of those you have elected to-night are well tried stalwarts, to whom you are indebted for their good services in past years. At the same time, I consider you have been wise in introducing new blood, and I have much pleasure in congratulating Messrs. Hilton and Hutton on their election, as they will, I am sure, contribute to the progress of the Society and work whole heartedly for its welfare. When the time arrives for your next election, I hope that the peace, which we so fervently desire and pray for daily, will have been achieved, and that it will spell long years of happiness and prosperity for your Society and its members.

The Secretary desires me to remind you of the special joint meeting of this Society and the S.A. Institution of Engineers, which will take place next Saturday evening at 8 p.m., in the Chamber of Mines, when two papers will be read. As one of these is being read by your new President, I hope there will be a good rally of members to support him.

The meeting then terminated.

Review.

The Banket: A Study of the Auriferous Conglomerates of the Witwatersrand and the Associated Rocks, by Robert B. Young, M.A., D.Sc., etc., Professor of Geology and Mineralogy at the S.A. School of Mines and Technology. Gurney & Jackson, London, 1917, 117 pp., with numerous photomicrographs.

In addition to its obvious interest to geologists, mining men and members of the public generally this monograph is of great importance to metallurgists and all engaged in the extraction of gold, for it gives the best account so far published of the world's most important source of the precious metal. It will naturally find a place on all well stocked bookshelves in the Witwatersrand district, and all practical men engaged in mining will find it advisable to keep a copy at hand, for all the facts of practical importance so far known are as carefully recorded as those of more theoretical interest. Among such practical facts may be mentioned the indications which correspond with the presence of unusual richness in gold, with the neighbourhood of dikes and those which indicate direction of movement in faults.

Dr. Young has by this publication shown his right to occupy a position which might usefully be made a focus of attraction for records of all the numerous observations, both of routine and of exceptional occurrences, frequently made but usually at present lost for scientific purposes. In this manner what are now regarded as peculiarities of a few mines will be recognised as being in actual fact of more widespread occurrence, as, for example, the presence of minute carbon nodules accompanying especially rich gold ore which have certainly been met with on more than the few mines the author mentions: similarly it would probably be difficult to mention a mine along the Reef in which no blende or copper pyrites has ever been found.

The important matter of the origin of the gold in the banket has been carefully considered, and the author leans heavily to the side which maintains the detrital origin. Emphasis, however, is laid on the opinion that the gold as we now have it has practically all been subject to solution and reprecipitation without significant migration. This opinion is fortified by the author's inability to recognise any "placer" features and to the total absence of nuggets.

The outstanding feature of this work is the abundance of beautiful microphotographs which illustrate fully all the usual features of the banket, together with many interesting local peculiarities. A full description of the habits of the numerous minerals usually or occasionally found in the banket shows how much more extensive is the list than is usually believed.

A short index is provided, but no separate bibliography is given, a defect which the next edition could profitably amend.

H. A. W.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

The Determination of Chromium in Ferrochromium.—"The following simple method for the determination of chromium in ferrochromium is stated to have proved, after a year's usage, both rapid and accurate.

The procedure consists in fusing the alloy with sodium peroxide, forming Na_2CrO_4, dissolving the melt, and, after boiling to destroy the excess of peroxide, which has a strong tendency to reduce chromium in acid solution, acidifying with sulphuric acid and titrating the resulting dichromate solution by the usual method with tenth normal ferrous sulphate solution. The following outline is worked out for ferrochrome which contains about 70% chromium: For alloys of different composition one may modify the amount of sample taken or the size aliquot titrated within reasonable limits.

Weigh accurately 1 gm. of finely pulverized alloy (50 mesh) and mix thoroughly with 25 gm. to 35 gm. sodium peroxide. This may be accomplished by stirring the mixture with a stiff platinum wire in either a nickel or an iron crucible of about 40 cc. capacity in which the fusion is to be made. A layer of sodium peroxide is placed on top of the mixture and the crucible gradually heated over a Bunsen burner to a dull cherry red until the contents are entirely fused. The flame is now lowered, keeping the mixture molten at a very dull red, nearly black heat for fifteen minutes. Gradually raise the flame once more to a dull cherry red and then allow the crucible to cool.

Place the crucible and contents in a one-litre beaker with 250 cc. of water. Cover and allow the reaction to proceed. When finished, remove the crucible and cover carefully, washing with hot water. Boil the contents of the beaker vigorously for about twenty minutes to destroy the excess of peroxide. Acidify with a considerable excess of ½ sulphuric acid and concentrate, if necessary, to a volume of about 300 cc. Cool and transfer to a 500 cc. volumetric flask and fill to the mark with water.

An aliquot of 50 cc. is now titrated in the usual way against freshly standardized $N/10$ ferrous sulphate solution. This may be conveniently carried out by filling a 100 cc. burette with the dichromate solution and titrating back and forth until a satisfactory end point is reached. The titration may also be carried out by adding an excess of standard $N/10$ ferrous sulphate solution to a 50 cc. portion of the solution prepared for analysis and titrating back to a blue end point with $N/10$ potassium permanganate solution. This end point may be properly identified by treating 50 cc. $N/10$ $K_2Cr_2O_7$ (standardized by pure iron) plus sulphuric acid in the way described. For the sharpest end point the solution must be perfectly cold. One cc. $N/10$ ferrous sulphate is equivalent to 0·001743 gm. chromium."—A. F. Macfarland.—*Metallurgical and Chemical Engineering*, xv., 6, Sept. 15, 1916, p. 279. (J. A. W.) [*Vide* Low. $KMnO_4$ is inferior on account of the interference of the green chromium salt with the pink end point. It is better to add an excess of solid ferrous ammonium sulphate and titrate back with $K_2Cr_2O_7$ as in Low. Ed. Com.]

Determination of Nitric Nitrogen.—"Nitrates in culture media and in soil extracts can be accurately estimated in presence of unstable amino-compounds by reducing with a zinc-copper couple at the boiling point of the solution, in presence of a small quantity of magnesia, and simultaneously distilling off the ammonia into excess of standard acid, the excess of acid being titrated at 37°—70° C. using *p*-nitrophenol as indicator. In the case of solutions containing a large amount of organic matter, previous shaking with alumina cream and filtering removes sufficient organic matter to prevent interference with the method. Details are given of a modified Kjeldahl distillation apparatus suitable for this method."—F. M. Scales, *J. Biol. Chem.*, 1916, 27, 327-337.—*Journal of the Society of Chemical Industry*, Dec. 30, 1916, p. 1273. (A. W.)

Thermalene.—"We learn with interest that a Swiss has invented what is termed 'thermalene gas,' which, in use, is far less dangerous than ordinary acetylene, being formed in tin cases charged with calcium carbide and oil-soaked sawdust in alternating layers. The case is placed in the generator, and water is gradually admitted from below. Acetylene is thus liberated in the usual manner but, in its passage through the sawdust layers, it becomes saturated with oil gas and is thus converted into thermalene. The mixture is heavier than air, and, in its gaseous state is less explosive than pure acetylene. The other important advantages claimed for thermalene are that its specific heat is only one-eighth that of acetylene, the flame is much better, and the gas requires less oxygen when burning. It is, however, for welding purposes that this gas may prove most successful, a soft weld being readily obtained, particularly in the case of cast-iron. A portable welding outfit consists of the generator, gas reservoir, oxygen cylinder, and a special form of torch. The supply pipes from the oxygen and gas storage vats are connected to a mixing chamber in the body of the torch in which special arrangements are provided for the prevention of flame back flash. Special provision has also to be made in the generating cartridge to prevent the oil and carbide from mixing, and this is attained by means of cardboard separation discs and metal spiral spacers. The lime and other impurities remain in the cartridge after gas has been liberated and are ejected with it. It, therefore, would appear that the methods of manufacture are clean and simple, and that thermalene, in respect of its manufacture and its properties, will eliminate many of the disadvantages which have hitherto militated against the use of pure acetylene."—*Indian Engineering*, Dec. 23, 1916, p. 411. (J. A. W.)

Detection of Thiocyanates.—"The reaction between ferric chloride and a thiocyanate is a very sensitive test for iron but not so for thiocyanates, since the maximum coloration depends on the presence of an excess of thiocyanate. Moreover, arsenates, phosphates, tartrates, fluorides, and borates interfere with the reaction, ferrocyanides mask the red colour, and iodides, acetates, and nitrites yield colorations with ferric chloride similar to that given by a thiocyanate. A method recommended for the detection of thiocyanates depends on the fact that silver iodide is not attacked by hot 5% sodium chloride solution, whilst silver thiocyanate is converted into silver chloride and sodium thiocyanate by this treatment. The solution to be tested is rendered just alkaline with sodium hydroxide, then barium nitrate, calcium nitrate, and cobalt nitrate are added in excess in the order given (this treatment removes sulphides, cyanides, ferrocyanides, and other interfering substances), the mixture is boiled, 3 gm. of washed asbestos added, and the solution filtered. The filtrate is acidified with nitric acid, silver nitrate is added, the mixture boiled, and the precipitate collected on a filter. The precipitate is washed, then boiled for 5 minutes with 10 cc. of 5% sodium chloride solution, filtered, the filtrate evaporated to 4 cc., acidified with a drop of 10% nitric acid and treated with 0·5 cc. of 2*N* ferric nitrate solution. The coloration obtained does not afford a means of determining the quantity of thiocyanate present, especially in the case of relatively large amounts; between 25 and 250 mgm. of thiocyanate there is no appreciable difference in the coloration. The quantity of mercuric chloride solution required to change the red colour to a definite brown tint furnishes, however, an approximate measure of the thiocyanate."—L. J. Curtman and B. R. Harris, *J. Amer. Chem. Soc.*, 1916, *38*, 2622-2629.—*Journal of the Society of Chemical Industry*, Jan. 15, 1917, p. 30. (J.A.W.)

Results of Co-operative Work on the Determination of Sulphur in Pyrite.—"The results obtained in 25 different laboratories by three different methods are tabulated and discussed. Allen and Bishop's method gives much more concordant results than Lunge's method, and is recommended as an accurate method for the determination of sulphur in pyrite. It has been modified as follows to allow of using a smaller sample: 0·5495 gm. of the powdered sample, dried at 100° C., is treated with 6—8 cc. of a mixture of 2 parts of bromine and 3 parts of carbon tetrachloride by volume, and left for 15 minutes in a tall covered beaker, with occasional shaking; 10 cc. of concentrated nitric acid is then added and after standing for 15 mins., with occasional shaking, the mixture is heated below 100° C. until most of the bromine has been expelled, and then evaporated to dryness on a steam plate. The residue is treated with 10 cc. of concentrated hydrochloric acid, the mixture evaporated to dryness, and the residue heated at 100° C. for ½—1 hour to dehydrate the silica, and then moistened with 1 cc. of concentrated hydrochloric acid and heated with 50 cc. or more of water until solution is complete. After cooling for 3—5 mins., 0·1 gm of powdered aluminium is added and when reduction is complete the solution is filtered, and the residue washed nine times with hot water. The solution is treated with 2·5 cc. of concentrated hydrochloric acid, then diluted to 650 cc., and 50 cc. of cold 5% barium chloride solution added slowly, without stirring, preferably in single drops at the rate of about 5 cc. per minute. The mixture is stirred, allowed to stand for at least 2 hours, and the precipitate collected on a thick layer of asbestos in a Gooch crucible, using suction. After washing with cold water, the precipitate is dried and ignited.

Smoot's method also gives good results but possesses no advantage over the above process and requires special apparatus."—H. C. Moore, *J. Ind. Eng. Chem.*, 1916, *8*, 1167-1170.—*Journal of the Society of Chemical Industry*, Jan. 15, 1917, p. 29. (J. A. W.)

Analysis of Babbitt Metal. *Preparation of the Sample.*—Break or saw the ingots squarely across and file after removing the roughness. If care is taken an accurate sample of the cross-section can be taken. A sample may also be taken by sawing through the ingot several times and collecting the sawings. These sawings or filings should be gone over with a magnet to remove any iron which might contaminate the sample.

Antimony.—One gram of the filings is dissolved in an Erlenmeyer flask (800 cc.) with 10 cc. of water and 25 cc. of sulphuric acid. When solution is complete and no black shows in the bottom of the flask remove from the hot plate and cool. Now add 100 cc. of water and 10 cc. of hydrochloric acid and boil 10 minutes to expel sulphurous fumes. Cool, and add 100 cc. of water and titrate with potassium permanganate.

Tin.—Half a gram of the sample is dissolved in HCl with the aid of a little $KClO_3$ if found necessary. Reduction is effected with Fe, after which the solution is titrated with 0·1 N. iodine solution.

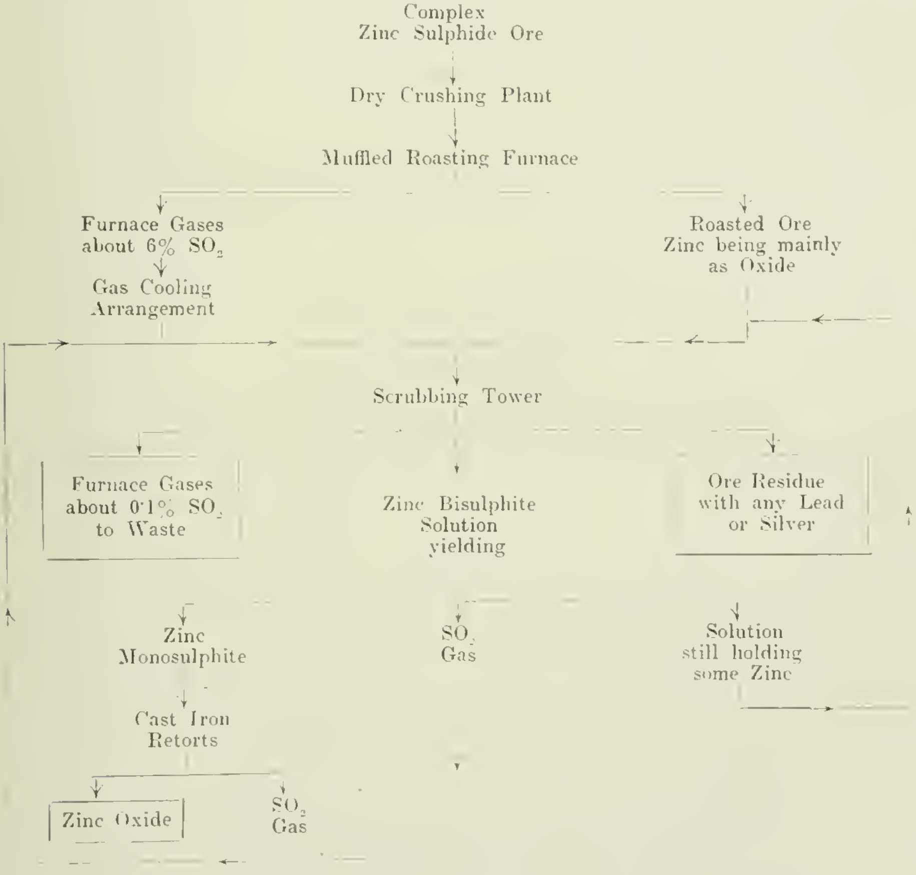
Lead.—The method given is solution of the lead, precipitation with H_2SO_4, solution of the $PbSO_4$, with ammonium acetate and final precipitation and weighing as $PbCrO_4$. (Ed. Com.: The latter could be eliminated by titration with ammonium molybdate solution).

Copper. The method given is the ordinary method by decomposition with KI and titration of the iodine with sodium thiosulphate solution.—E. W. HAGMAIER.—*Metallurgical and Chemical Engineering*, Jan. 15, 1917, Vol. xvi., No. 2, p. 84. (J. A. W.)

FLUORINE IN SOLUBLE FLUORIDES. — "A neutral solution of the fluoride is heated to boiling and powdered calcium sulphate is added; after standing for 1 hour, with frequent stirring, the precipitate, consisting of calcium sulphate and calcium fluoride, is washed several times by decantation and then collected on a filter. The latter consists of a disc of filter-paper fitted into the bottom of a perforated platinum crucible. The precipitate is now washed (the wash-water used should be saturated previously with calcium sulphate and calcium fluoride), then rinsed into an ordinary platinum crucible and the water evaporated; the disc of filter paper is, meanwhile, ignited on the crucible lid and the ash introduced into the crucible. The dry contents of the crucible are then heated at 300° C. for 1 hour, or until constant in weight, then sulphated, again heated at 300° C., and weighed. The increase in weight after sulphating is due to the replacement of two atoms of fluorine by the sulphuric acid radicle, and a simple calculation gives the quantity of fluorine present. The error of the method is about 0·1%."—J. G. DINWIDDIE, *Amer. J. Sci.*, 1916, *42*, 461-468.—*Journal of the Society of Chemical Industry*, Jan. 15, 1917, p. 30. (J. A. W.)

METALLURGY.

THE BISULPHITE ZINC PROCESS.—"The procedure as first tried about ten years ago provides for roasting the ore in a muffle furnace at a finishing temperature of about 950° C. so that no zinc remains as sulphate; therefore the majority of zinc is oxide. By using a muffled furnace the gases from the ore are rich in SO_2, say, 5% to 7%. Hence, by the aid of a scrubbing tower a weak solution of SO_2 is obtained at a nominal cost; but after once starting up, since theoretically all the SO_2 used is returned to the circuit, only enough SO_2 has to be absorbed daily in the scrubbing tower to make up for losses.


Complex Zinc Sulphide Ore
Dry Crushing Plant
Muffled Roasting Furnace
Furnace Gases about 6% SO_2
Gas Cooling Arrangement
Roasted Ore Zinc being mainly as Oxide
Scrubbing Tower
Furnace Gases about 0·1% SO_2 to Waste
Zinc Bisulphite Solution yielding
Ore Residue with any Lead or Silver
Zinc Monosulphite
SO_2 Gas
Solution still holding some Zinc
Cast Iron Retorts
Zinc Oxide
SO_2 Gas

Flow Sheet showing Modification of Bisulphite Process.

The defects in the procedure outlined were so numerous that the process had to be abandoned. The high temperature of the finishing roast in the muffle-roasting furnace causes zinc to combine with iron oxide and thereby produce zinc compounds which do not yield their zinc to the acid solvent.

There will be some zinc sulphate in the ore when the roast is finished, and the solutions in being handled by pumps will gradually oxidize to sulphate. No satisfactory plan was provided for dealing with this ever-growing quantity of sulphate of zinc in solution.

No air compressor was found of any use for any length of time for pumping the SO_2 gas into the revolving barrel.

All construction and maintenance costs were high because all pipes were lead. all valves were either antimonial lead or some special brass, all vats were lead-lined, and because all iron work had to be protected continually, the atmosphere being moist and always with traces and sometimes with large amounts of SO_2 in it.

The net result of the work, as here roughly outlined, was that no further attempt was made to use SO_2 as gas. This work had been carried out on a scale of up to about three tons per day, and the decision to abandon the use of SO_2 as gas was not arrived at till most exhaustive work had been carried out and till it was evident that commercial success was impossible, one of the principal (of the many) difficulties being that almost every vat or vessel had to be covered air-tight, therefore no operation could be easily watched or controlled.

Modification of the Process.—The next procedure used is shown in flow sheet. At first sight it had many advantages, and although some objections were obvious, no vital objections appeared till the procedure was put into operation. The partly-cooled sulphur gases from the roasting furnace were passed up a scrubbing tower, down which there was fed roasted ore with water or solution from which the bulk of the zinc had been removed.

When water alone is run down a scrubbing tower, only a 1% (or less) solution of SO_2 can be obtained; but when the water also conveys zinc oxide (that is, roasted ore) which combines *chemically* with the SO_2 then a greater percentage of SO_2 can be caught, equal approximately to the percentage in the original furnace gases, in this case usually from 5% to 6%; therefore in the case of ore and water (or solution) together running down the scrubbing tower, the final solution will contain at least six times as much SO_2 as is the case when water alone is used to absorb the SO_2.

The ore and solution, after finally leaving the scrubbing towers, was collected in vats, washed, and the solutions separated much the same as in cyanide work. At first the method of precipitation consisted in heating bisulphite solutions to near the boiling point so that half the SO_2 was liberated and about half the zinc, on cooling, was precipitated as an insoluble monosulphite of zinc ($ZnSO_3$ xH_2O). Heating to about 600° C. converted the latter compound to zinc oxide.

Finally, after a large amount of experimental work, it was found that the only positive method of precipitation suitable for the case in question was to work the solutions up in zinc contents till they contain 10% or more of zinc as metal and then evaporate them to dryness; that is, until on cooling the whole mass consisted of $ZnSO_4 7H_2O$ (ordinary sulphate of zinc) crystals.

General Difficulties of the Process.—The solubility of $ZnSO_3$ in cold water, normally about 0·5%, is decreased by the presence of zinc oxide. In the presence of water $ZnSO_3$ is easily converted by SO_2 into zinc bisulphite, a compound which only exists in solution, but which is very soluble in water. A solution containing about 10% of zinc as bisulphite can be easily prepared. Zinc-bisulphite solutions gradually deposit $ZnSO_3$ by evolution of SO_2.

Zinc monosulphite ($ZnSO_3 \times H_2O$) is a crystalline compound and sets to a hard compact mass which cannot easily be broken up even with a pick axe or drill. Similarly any roasted ore containing zinc, if treated with enough SO_2 to form $ZnSO_3$ and allowed to settle for a short time, will set to a hard compact mass which is as hard as 'set plaster of Paris.' The facility with which this $ZnSO_3$ sets hard is a point of great difficulty in commercial work.

Both in solution and in the solid state $ZnSO_3$ oxidizes rapidly to zinc sulphate. The same remark applies to the bisulphite solution; but in either case it is difficult, by atmospheric oxidation only, to convert *all* the zinc into sulphate.

The sulphur gases from the roasting furnaces leave the furnace at a temperature of from anything down to, say, 250° C. These gases cannot be brought into contact with ore and water in order to form zinc bisulphite, unless their temperature has been lowered sufficiently so that the mixture of ore and water will not be raised much above atmospheric temperature. If a mixture of ore and water be heated appreciably by the gases, then zinc bisulphite will be decomposed or not formed at all, and instead of the zinc oxide being made into the soluble bisulphite, it will remain with the ore as the almost insoluble monosulphite. This is important and brings up the question of cooling the sulphur gases.

The roasting of a complex ore is not by any means too simple an operation. In addition to zinc, lead and silver, such an ore may contain also iron, silica, copper, arsenic, antimony, etc. In general if an ore is roasted at such a temperature that practically none of the zinc remains as sulphate, then it will be found that a large percentage of the zinc present is *not* soluble in SO_2. Conversely, if roasted at a temperature very gradually rising up to but not above 650° C., then 90% to 95% of the zinc contents will be soluble in SO_2. (It is in general assumed that such ores contain about 25% to 30% of zinc.) In the fore-going case of low-temperature roasting, from 30% to nearly 50% of the zinc will be as sulphate after the roast and would therefore be soluble without any SO_2. With this low-temperature roasting, some iron will probably be water-soluble or SO_2-soluble.

Sulphuric acid causes silica to pass into solution, but SO_2 does not have this effect. When silica does pass into solution, it may appear later as gelatinous silica, if for any reason the solution becomes neutral.

Some General Conclusions.—Sulphurous acid can be of no utility as a solvent for zinc oxide from ores except in those localities where it is cheaper to use it on the lines indicated than to buy sulphuric acid. It is a question of geography and freights this is important; it does not necessarily mean that, even if the ore in question is mined in quantity, it may not pay better to bring it to where acid can be bought.

If sulphurous acid (SO_2) is used as resulting from the roasting of complex zinc ores, it may be possible to attain commercial success by roasting the ore so as to produce the maximum amount of water-soluble zinc sulphate and at the same time a good percentage of the remaining zinc as soluble in SO_2 (or H_2SO_4). The portion of the zinc that is dissolved by SO_2 will yield a bisulphite solution. This solution by aëration should be oxidized to sulphate; thus all the zinc in solution will be sulphate. The neutral solutions after purification by zinc dust can be worked up in zinc contents so that a certain daily portion of the solution assaying about 10% zinc will be evaporated till the density shows that there is practically nothing but sulphate of zinc melted in its own water of crystallization. The cooled mass will solidify, and it can be roasted in a reverberatory furnace to produce zinc oxide.

If a wet method is required for any zinc ore, from a metallurgical point of view sulphuric acid will do as well as SO_2."—*Engineering and Mining Journal*, Nov. 18, 1916, p. 895. (H. A. W.)

MINING.

The Payment of Overtime on Transvaal Mines.—"At a meeting of the Association of Mine Managers held on the 25th June, 1915, it was resolved:—

That the Association is of opinion that every effort should be exhausted to maintain the conditions for the payment of overtime as they are to-day.

If, however, it proves absolutely necessary to compromise, the following suggestions are put forward as a maximum concession:—

General.—That clocks or some other method of time-keeping be made use of in shops and at the heads of main shafts which will enable correct time to be recorded.

Surface Work.—1. That men be paid on an hourly basis both for ordinary time and overtime.

2. That shop hours reckoned as ordinary time shall not exceed 50 hours per week

3. That, except when overtime is worked in continuation of ordinary time, one hour be added to the overtime actually worked, and that such hour be paid for at ordinary rates. For the purpose of this clause, resumption of work after any break for meals is to be regarded as a continuation of ordinary time.

4. That for all time above 56 hours per week surface work be paid at the rate of time and a quarter, except in such cases where a workman's condition of employment normally includes seven days work or more, as, for example, engine drivers, banksmen, reduction men, etc.

5. That the Management shall have the right to lay off men who work overtime for a corresponding period.

The Association is of opinion that this last clause is absolutely necessary to prevent excessive overtime, and would suggest that agreement to the previous clauses be contingent on the acceptance by the men of this clause.

Underground Work.—1. That overtime be paid for on an hourly basis.

2. That all Sunday work be regarded and paid for as overtime, except in the case of those men who work regular shifts on Sundays, as, for example, engine drivers, pumpmen, skipmen, etc., but excluding shaft timbermen.

3. That all overtime be paid for at the rate of time and a quarter.

4. That the 48 hours' Act be universally enforced, so that men working on a Sunday be laid off for an equivalent time within 10 days of working such overtime.

It must be realised that whatever regulations are made the Management of a mine must always use discretion in special cases, such as serious breakdowns, but it is recommended in such cases that any extra pay be made in the form of a bonus and not in additional hours or a higher rate of pay per hour."—Appendices to Reports on Time and Labour Saving on the Mines.—Association of Mine Managers of the Transvaal, July 2nd, 1915. (G. H. Sm.)

Alternative Employment as a Preventative of Miners' Phthisis in the Transvaal.—"The subject of the value of alternative surface employment for white employees as a preventative of miners' phthisis has recently received careful consideration by the Transvaal Chamber of Mines.

The Sub-Committee desires to draw attention to the need for a uniform policy by which employees, more particularly underground employees, are urged to avail themselves of the generous holiday leave regulations, and are induced, after periodical medical examination, which would suggest to them the advantage of a change to some surface occupation, to avail themselves of every opportunity to acquire some knowledge of an alternative employment.

In this connection employers are urged to utilise the clause in the holiday regulations to encourage applications for an extension of leave to underground employees, so that time may be found to acquire a more complete knowledge of an alternative employment. A most desirable class of citizen, who has a first-hand knowledge of mining and yet can make a living in another occupation, would thus be created within the Union."—Appendices to Reports on Time and Labour Saving on the Mines.—Association of Mine Managers of the Transvaal, March, 1916. (G. H. Sm.)

Labour in Reduction Works.—"*Partial or Total Elimination of Natives.*—The partial substitution of white for coloured labour does not appear to be feasible, for whites will not work on the same footing as natives. The total substitution of whites for natives in reduction works was considered from the following points of view:—

(1.) Class of whites to be employed. (2.) Supply of this class of labour. (3.) Efficiency of whites as compared with natives. (4.) Cost of white labour. The class of labourer required would be of the navvy type, and it is a question whether many of this type are available in the country. It is considered that such white labour would not be satisfactory nor, in some cases, as efficient as native labour on these fields.

This was proved at the trial of white labour for discharging sands at the Consolidated Main Reef.

The pay of such labour should not be less than 7s. 6d. per day, and suitable quarters would have to be found. It appears that very little, if any, saving in the number of employed could be effected, and therefore the cost would be about three times as much as at present.

Transport and Disposal of Sand and Slime.—There is little to choose between any of the methods at present in use.

Relative Merits of Gold Recovery combined with the Mechanical Work or conducted under Separate Supervision, i.e., Plates detached from Mill.—The advantage of the latter method is that *no* natives are required in the plate house, and there is consequently no chance of leakage of gold through them.

With regard to labour saving, there is not much to choose between the two systems."—Appendices to Reports on Time and Labour Saving on the Mines.—Association of Mine Managers of the Transvaal, May, 1915, p. 42. (G. H. Sm.)

Abstracts of Patent Application

(C.) 176/16. Henry Livingstone Sulman (1), Edwin Edser (2). Improvements in or relating to the concentration or ores. 20.7.16.

This application is for a means of concentrating ores by flotation methods, in which the mineral content is partly or wholly oxidised, and consists in substituting soluble soap in a neutral or alkaline circuit, for the usual oil and acid. Further, in adding to the circuit a small proportion of a substance which causes the gangue material to be wetted by the water, but does not decompose soap, such as sodium silicate, silicic acid "sol," etc.

(C.) 15/17. James Eason. A renewable head for tappets. 19.1.17.

This application relates to an improved tappet in which a renewable head or wearing face is shrunk on at each end in dove tail fashion.

(C.) 70/17. Henry Livingstone Sulman (1), Hugh Fitzalis Kirkpatrick Pichard (2). Improvements in or relating to the extraction of zinc. 24.2.17.

This application relates to the treatment of zinc bearing ores or zinc-containing materials, and it refers more particularly to the preparation of a solution of zinc by dissolving the metal with an acid.

It claims specially to overcome certain difficulties which are met with in carrying out such a process, and intimates, by various references to the present state of the art, that the invention is new and of economic value.

(C.) 73/17. Edwin Edser (1), Henry Livingstone Sulman (2). Improvements in or relating to the concentration of ores. 26.2.17.

This application relates to means to overcome the difficulties experienced in flotation concentration of ores containing gangue cosisting of clay, slate, mica, kaolin or calcite, and consists in subjecting the ore to the action of silicic acid sol, either before or during flotation concentration.

(C.) 169/16. James Alexander Tod. A method and means of utilising a hydrostatic force. 12.7.16.

This application is for an apparatus which provides a self working condenser and ever ready vacuum. It is a combination of a barometric condenser, together with an air-cooled leg, on the side on which the water descends, in order to make the apparatus automatic with regard to cooling.

(C.) 128/17. Albert Francois. New or improved method of making fissured water-bearing strata water-tight. 21.3.17.

This application relates to a method of making fissured water bearing strata water-tight, wherein the fissures are prepared to receive cement by introducing into same a gelatinous precipitate obtained in a known manner by mixing together suitable solutions.

It also relates to a method of making fissured water-bearing strata water-tight wherein cement milk is injected, and when it is found that the cement does not normally penetrate the ground, cementation is left off and a ready prepared mixture of suitable chemical solutions is injected in the form of a liquid holding a gelatinous precipitate in suspension, after which the injection of cement milk is resumed.

(C.) 117/17. Rhetherford Brawdus Martin. Improvements in ore concentration. 20.3.17.

This application relates to improvements in the concentration of ores by flotation.

The claim is for a process patent for the preparation of froth-flotation agents for the concentration of ores, which consists in mixing an oil with sulphur and subjecting the mixture to heat at a specified temperature.

The modification of the oil resulting from this treatment is said to enhance its air-emulsifying properties, whereby an improved, and more economical result is obtained as compared with other known agents.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Banks, J. H. G., *to* c/o Waihi G.M. Co., Ltd., Waikino, Auckland, New Zealand.
Cook, J. F., *l/o* Johannesburg; Whitney Point, New York, U.S.A.
Gardiner, B. L., *to* Connemara Mine, Private Bag, Bulawayo, Rhodesia.
Innes, C. R., *l/o* Germiston; 316, Persimmon Street, Malvern.
Jenkin, A., *l/o* Knights; P.O. Millsite, Randfontein.
Marquard, J. D., *to* Inspector of Mines Office, Krugersdorp.
Philpott, R. C., *to* P.O. Box 1423, Cripple Creek, Colorado, U.S.A.
Yates, Prof. J., *to* Sunnyside, 8th Avenue, Parktown North, Johannesburg.

INDEX.

INDEX TO VOL. XVII., 1916-1917.

(COMPILED BY PROFESSOR J. A. WILKINSON.)

The portions in Italics refer to Original Notes and Papers read before the Society

A

PAGE

Absorbent for CO_2 in Steel Analysis. A New G. L. Kelley 193
Abstracts of Patent Applications 24, 56, 108, 116, 124, 164, 180, 204, 236
Accelerating Hardening of Concrete, Calcium Chloride for 108
Acceleration of Kjeldahl's Method of Determining Nitrogen in Coal and Coke B. M. Margosches and A. Lang ... 4
Accidents, Body Chart for Non Fatal A. H. Fay 77
Accommodation, Social Status—Better .. 123
Acid and the Dissociation Constant of the Acid, The Time Reaction in the Neutralisation of Carbonic L. Pusch 140
—— by the Citro Uranium Method, Determination of Phosphoric D. Crispo and R. W. Tuinzing 141
——, Determination of Small Quantities of Hydrocyanic M. O. Johnson ... 104
—— in the Manufacture of Ammonium Sulphate, Methods for Dealing with Arsenical Sulphuric P. Parrish .72
——, Investigation of the Chief Methods of Detecting Hydrocyanic G. Anderson 176
Action of Dolerite on Coal, The 184
Activities, Industrial 209
Adanti, G.—Volumetric Determination of Mercury 193
Adam, H. R.—Ore Treatment at the Falcon Mine (Rhodesia). 91
Discussion 94, 95, 96, 118, 137
Reply to Discussion 226
——, *Remarks by Mr. H. R., on Flotation Concentration Experiments on a Transvaal Gold Ore* 90, 136
——, H. R.—on Testing the Strength of Explosives 69
Advances in Chemical Industry, Recent, Presidential Address Professor J. A. Wilkinson 27
Advantages of Stronger Detonators ... 116
—— of Turbo Air Compressors 146
African Drugs and Poisonous Plants, South 103
Africa, Solanaceous Drugs from 51
Agitation Vat, Laboratory 76
Agitator, Slime 105
Aid on the Mines, First T. P. Waites .. 211
Alaska Gold Mines 114
Alexander, Remarks by Mr. W.—on the Hardening and Annealing of Metals 102
Alkali Industry 33
—— Metals, Separation of Lithium from other S. Palkin 193
Allen, A. W.—Clay in Ore Dressing and Cyaniding 23

PAGE

Alloys, Analysis of Aluminium and its W. H. Withey 4
Alloy Steel Castings David Evans .. 178
—— Substitutes for Gold and Platinum F. A. Fahrenwald .. 104
Aloes, New Colour Reaction for C. E. Stacy 118
Alternative Employment as a Preventative of Miner's Phthisis in the Transvaal 235
Altitudes, Computing Gas Engine Horse Power at High 55
Aluminium and its Alloys, Analysis of W. H. Withey 4
—— as Oxide, Determination of W. Blum 141
—— in Aluminium Dust, Estimating Metallic J. E. Clennell 159
Amalgams in the Recovery of Gold, The Relative Efficiency of Various Thomson and Keffer 6
Ambulance Competitions, Annual 209
—— ——, Mine 149
—— Shield Competition, Underground 165
American Production of Potash 73
Ammonium Salts, New Applications of Thymolphthalein and Naphtholphthalein, including Rapid Methods for Analysing Limestone and J. Moir 158, 174
Discussion 158, 174
—— Sulphate, Methods for Dealing with Arsenical Sulphuric Acid in the Manufacture of P. Parrish .. 72
Anaconda, Hardinge Mills at F. Laist and A. E. Wiggin . .. 105
Analysis, A New Absorbent for CO_2 in Steel G. L. Kelley 193
—— of Aluminium and its Alloys W. H. Withey 4
—— of Babbitt Metal E. W. Hagmaier 232
—— of Lime Sulphur Solutions, New Methods for the R. M. Chapin 104
—— of Turbadium Bronze H. Williams 7
Analytical Standard, Potassium Bichromate as an I. G. Bruhns 109
Anderson, G.—Investigation of the Chief Methods of Detecting Hydrocyanic Acid 176
——, R. T.—Oils and other Reagents in Ore Flotation ... .
A New Absorbent for CO_2 in Steel Analysis G. L. Kelley ... 193
—— Method of Zinc Precipitation H. R. Conklin 200
—— Track and Rail Joint L. W. Macer 127
Annealing of Metals, The Hardening and Prof. T. Turner 61
Discussion 100
Annual Ambulance Competitions 209
—— General Meeting 205
—— Report of Council 205

PAGE

A Novel Method of Handling Boilers to Prevent Corrosion and Scale A. H. Babcock 146
Antimony Gold Ore, Flotation Test on E. R. Pilgrim 162
Antisell, F. L. and S. Skowronski.—Electrolytic Refining of Copper 145
Apparatus, The Shore Scleroscope Testing... 101
Applications of Thymolphthalein and Naphtholthalein, including Rapid Methods for Analysing Limestone and Ammonium Salts J. Moir ... 129
Discussion 158, 174
—— of X Rays to Metallurgy 101
A Remedy for Slippery Iron Floors W. A. Lailer 177
Arsenical Sulphuric Acid in the Manufacture of Ammonium Sulphate, Methods for Dealing with P. Parrish ... 72
Arsenic, Iron, Thallium, Zirconium and Titanium, Qualitative Separation of Tellurium P. E. Browning, G. S. Simpson and L. E. Porter ... 142
Artificial Medicines, Industry of 35
—— Perfumery Industry 35
—— Transformation of Nitrogen 30
Asbestos Industry, Cape G. E. B. Frood 180
A Self Cleaning Strainer for Mine Pipes .. 8
Ash on Acid Sand in Stope Filling, Neutralisation Effect of Chris. Toombs 84
Discussion 87, 135
Do. Reply to 188
Assayer's Certificates, Regulations ... 196
Assay of Lead, Rapid G. Torossian ... 159
—— of Tin Ores, Chemical A. M. Matheson 143
Atmospheres Deficient in Oxygen, Effect of G. A. Burrell and G. G. Oberfell 201
Atomic Weights of the Elements G. P. Baxter 111
Attendance at Council Meetings 209
Awards and Grants 208

B

Babbitt Metal, Analysis of E. W. Hagmaier 232
Babcock, A. H.—A Novel Method of Handling Boilers to Prevent Corrosion and Scale 146
Bakelite Industry 36
Balance Sheet for Year 207
Ball Mills 54
Banana Stalks, Potash in R. H. Ellis... 103
Bantjes Consolidated Mines, Concrete Shaft Equipment at the W. W. Lawrie and G. Hildick-Smith Reply to Discussion 96
Baxter, G. P.—Atomic Weights of the Elements 111
Beach, A. F. Taggart and F. E.—Flotation Processes 195
Bearing Ores, Cyaniding Copper P. W. Gaebelein 119
Bearings *v.* Plain Bearings on Mine Cars, Roller 145
Bell, J. W.—Rock Crushing 197
Beryllium 161
Better Accommodation, Social Status .. 123
Bichromate as an Analytical Standard Potassium I. G. Bruhns 109
Bisulphite Zinc Process, The 233
Blast Furnace, Tapping Matte from ... 94
Blister Copper, Pouring 95
Blowholes in Castings by X Rays, Detection of C. H. Tonamy 75
Blum, W. Determination of Aluminium as Oxide 141
Body Chart for Non-Fatal Accidents A. H. Fay 77
Boilers, Corrosion of E. Bosshard and R. Pfeninger 72
Boilers to Prevent Corrosion and Scale, A Novel Method of Handling R. H. Babcock 146
Book Reviews 71, 230
Books, New 71, 158, 180
Bosshard, E. and R. Pfenniger.—Corrosion of Boilers 72
Bowman, F. C. and W. W. Scott.—Titration of Nitrates with Ferrous Sulphate 104
Box, Safety Trolley Wire 55
Bragg, W. H.—Crystal Structure of Metals Examined by X Rays 115
Brass, Electrolytic Deposition of A. Hönig 176
Brett, A. J.—The Encouragement of First Aid on the Mines Discussion 45, 97, 98, 99, 100
Reply to Discussion 133
—— , *Remarks by Mr. H. T.—on Ore Treatment at the Falcon Mine (Rhodesia) Discussion* 118
Brewery, Visit to Chandler's 181
Bricks, Testing Fire 142
Bronze, Analysis of Turbadium H. Williams 7
Browning, G. S. Simpson and L. E. Porter, P. E.—Qualitative Separation of Tellurium, Arsenic, Iron, Thallium, Zirconium and Titanium 142
Bruhus, I. G.—Potassium Bichromate as an Analytical Standard 109
Buck, D. M. and J. O. Handy.—Non-Corroding Steel 119
Bullion (Cyanide), Segregation in Gold J. H. Hance 110
Bureau of Standards, United States, Melting Points and other Standard Temperatures 49
Burrell and G. G. Oberfell, G. A. Effect of Atmospheres Deficient in Oxygen .. 201
Butters, C. and J. E. Clennell.—Cyanide Treatment of Flotation Concentrate 21

C

Cake, Utilisation of Nitre J. Grossmann 159
Calcium Chloride for Accelerating Hardening of Concrete 108
—— in Alloys and as a Deoxidiser ... 161
Caldecott Remarks by Dr. W. A.—on Ore Treatment at the Falcon Mine (Rhodesia) 95
Californian and Nissen Stamps at Modder B., Comparison of Stamp Milling Costs between K. L. Graham ... 118
Discussion 128
do. Reply to 176
Callow, J. M.—The Callow Pneumatic Oil Flotation Process ... 7
Campbell, J. A.—Testing the Strengths of Explosives 66
Reply to Discussion 135
Cam Shafts, Thermit Welding of ... 75
Canada, Zinc in Dr. Stansfield ... 5

PAGE

Canaries, Tests with ... 201
Cancellation of Certificates, Suspension and 191
Cape Asbestos Industry G. E. B. Frood 180
CO_2 in Steel Analysis, A New Absorbent for G. L. Kelley ... 193
Carbonic Acid and the Dissociation Constant of the Acid, The Time Reaction in the Neutralisation of L. Pusch 140
Carborundum ... 33
Carnotite, Radium from Parsons, Moore, Lind and Schaefer ... 72
Cars, Roller Bearings *v.* Plain Bearings on Mine ... 145
Carter, Grothe and—Improvised Stamp Shoes 8
Castings, Alloy Steel David Evans ... 178
—— by X Rays, Detection of Blowholes in C. H. Tonamy ... 75
Cells, Regeneration of Sulphated Storage G. A. Preley and C. W. Davis ... 109
Cellulose Industries ... 36
Cement, Portland G. A. Raukin ... 140
Certificates, Regulations—Assayers' ... 190
Chandler's Brewery, Visit to ... 181
Changes in Crushing and Grinding, The Year's Algernon del Mar ... 21
Changes of Address 8, 24, 56, 80, 108, 124, 148, 164, 180, 204, 236
Chapin, R. M.—New Methods for the Analysis of Lime Sulphur Solutions 104
Chart for Non-Fatal Accidents, Body A. H. Fay ... 77
Chemical Assay of Tin Ores A. M. Matheson ... 143
—— Industry, Materials of Construction in 27
—— ——, Photographic ... 35
—— ——, *Recent Advances in, Presidential Address Prof. J. A. Wilkinson*... 27
—— Methods of Tin Extraction O. J. Stannard ... 144
—— Research on Superphosphates, Technological N. Pratolongo ... 191
Chemistry in the United States, Electro ... 51
Chilean Mills and Tube Mills, Stamps ... 53
Chilton, Remarks by Mr. J.—on Silicosis in Rats in a Witwatersrand Mine ... 174
Chromium in Ferro-chromium, The Determination of A. F. Macfarland ... 231
——, Growing Importance of ... 161
Chlorine in Town Water Supplies, Determination of Free G. A. Le Roy ... 142
Chute for Flat Stopes, Shaking S. Nettleton ... 57
—— *for Flat Stopes, Shaking S. Nettleton* ... 57
Discussion ... 60
Citro Uranium Method, Determination of Phosphoric Acid by the D. Crispo and R. W. Tuinzing ... 141
Clay in Ore-Dressing and Cyaniding A. W. Allen ... 23
Clayton, C. Y.—Laboratory Experiments on the Flotation of Ores ... 162
Cleaning Strainer for Mine Pipes, A Self 8
Clennell, C. Butters and J. E.—Cyanide Treatment of Flotation Concentrate 21
——, J. E.—Estimating Metallic Aluminium in Aluminium Dust ... 159
Coal and Coke, Acceleration of Kjeldahl's Method of Determining Nitrogen in B. M. Margosches and A. Lang ... 4
Coalfields—Phases in Development, The Natal Wm. Taylor Heslop .. 182
Discussion ... 227
Coal for Markets, Preparation of .. 187
——, Influence of Iron Pyrites on the Oxidation of T. J. Drakeley .. 177
—— Mines, Occurrence of Explosive Gases in N. H. Darton ... 162
——, The Action of Dolerite on ... 184
——, The Structure of M. C. Stopes and R. V. Wheeler ... 177
——, The Winning of ... 185
Cobalt Salts, Detection of Nickel in A. R. Middleton and H. L. Miller . 192
Cohesion of Metals, Surface Tension and S. W. Smith ... 199
Colliers, The Health of Old Age J. S. Haldane . 55
Colloid, Iceland Moss as a Protective A. Gutbier, J. Huber, E. Kuhn and J. Krauter ... 141
Colour Reaction for Aloes, New C. E. Stacy ... 118
Combustion, Surface ... 108
Commercial Tin, Impurities in ... 143
Committee, Scientific and Technical ... 149
Comparison of Stamp Milling Costs between Californian and Nissen Stamps at Modder B. K. L. Graham ... 118
Discussion ... 128
do. Reply to ... 176
Competitions, Annual Ambulance ... 209
——, Mine Ambulance ... 149
Competition, Underground Ambulance Shield 165
Compressors, Advantages of Turbo Air ... 146
Computing Gas Engine Horse Power at High Altitudes ... 55
Concentrate, Cyanide Treatment of Flotation C. Butters and J. E. Clennell ... 21
Concentration Experiments on a Transvaal Gold Ore, Flotation F. Wartenweiler ... 87
Discussion ... 117, 136
do. Reply to ... 189
Concrete, Calcium Chloride for Accelerating Hardening of ... 108
—— *Shaft Equipment at the Bantjes Consolidated Mines W. W. Laurie and G. Hildick-Smith Reply to Discussion* ... 96
Conductivity of Materials Employed in Furnace Construction, Thermal E. Griffiths ... 192
—— of Refractories, Thermal ... 73
Conglomerates of the Witwatersrand E. T. Mellor Reply to Discussion... 41
Conklin, H. R.—A New Method of Zinc Precipitation ... 200
Constant of the Acid, The Time Reaction in the Neutralisation of Carbonic Acid and the Dissociation L. Pusch ... 140
Construction and Maintenance of Slime Dams, The J. E. Thomas and E. A. Osterloh (Note) ... 214
—— in Chemical Industry, Materials of .. 27
——, Thermal Conductivity of Materials Employed in Furnace E. Griffiths 192
Consumption in Westralian Mines, Water. . 163
Contributions and Correspondence 109, 118

PAGE
Co-operative Work on the Determination of Sulphur in Pyrite, Results of H. C. Moore 232
Cooper, R. A.—Sugar for Dust Filters ... 165
Discussion 166, 182
Copper Bearing Ores, Cyaniding P. W. Gaebelein 119
Copper, Electrolytic Refining of F. L. Antisell and S. Skowronski .. 145
——, Pouring Blister 95
Corroding Process, New Lead .. . 191
Corroding Steel, Non D. M. Buck and J. O. Handy 119
Corrosion and Scale, A Novel Method of Handling Boilers to Prevent A. H. Babcock 146
—— of Boilers E. Bosshard and R. Pfenniger 72
——, The Prevention of 110
Council, Annual Report of 205
Costs between Californian and Nissen Stamps at Modder B., Comparison of Stamp Milling K. L. Graham ... 118
Discussion 128
do. Reply to 176
Council Meetings, Attendance at 209
——, Scrutineers' Report and Declaration of Election of Officers and 210
Crispo, D. and R. W. Tuinzing.—Determination of Phosphoric Acid by the Citro Uranium Method 141
Crosse, Remarks by Mr. A. F.—on New Applications of Thymolphthalein and Naphtholphthalein ... 129, 174
——, —— *on Notes on Treatment of Pilgrims Rest Ore* 172, 173
——, ——, *The Solubility of Lime* ... 125
Discussion 126
Crushing and Grinding L. D. Mills and M. H. Kuryla 51
—— —— The Year's Changes in Algernon del Mar 21
——, Primary 51
——, Rock J. W. Bell 197
—— Tests, Standardising Rock M. K. Rodgers 112
Crystal Structure of Metals Examined by X Rays W. H. Bragg 115
Curtman and B. R. Harris, L. J.—Detection of Thiocyanates 232
Cyanide Eczema or Rash D. M. Liddell 142
—— Solutions, Solvent Power of H. R. Edmands 160
—— ——, Warning E. A. Wraight ... 22
—— Treatment of Flotation Concentrate C. Butters and J. E. Clennell ... 21
Cyaniding, Clay in Ore Dressing and A. W. Allen 23
—— Copper Bearing Ores P. W. Gaebelein 119

D

Dams, The Construction and Maintenance of Slime J. E. Thomas and E. A. Osterloh (Note) 214
Dangers of Firedamp, The 183
Darton, N. H.—Occurrence of Explosive Gases in Coal Mines 162
Data, Stamp Milling 52
——, Tube Milling 53
Davis, G. A. Perley and C. W.—Regeneration of Sulphated Storage Cells ... 109
PAGE
Declaration of Election of Officers and Council, Scrutineers' Report and ... 210
Defenders, Ear A. J. Herald 81
Discussion 82
Deficient in Oxygen, Effect of Atmospheres G. A. Burrell and G. G. Obertell ... 201
Department of Scientific and Technical Research 147
Deposition of Brass, Electrolytic A. Hönig 176
Detecting Hydrocyanic Acid, Investigation of the Chief Methods of G. Anderson 176
—— of Blowholes in Castings by X Rays C. H. Tonamy 75
—— of Nickel in Cobalt Salts A. R. Middleton and H. L. Miller ... 192
—— of Thiocyanates, L. J. Curtman and B. R. Harris 232
Determination of Aluminium as Oxide W. Blum 141
—— of Chromium in Ferrochromium, The A. F. Macfarland 231
—— of Free Chlorine in Town Water Supplies G. A. Le Roy ... 142
—— of Mercury, Volumetric G. Adanti 193
—— of Nitric Nitrogen F. M. Scales... 231
—— of Phosphoric Acid by the Citro Uranium Method D. Crispo and R. W. Tuinzing 141
—— of Small Quantities of Hydrocyanic Acid M. O. Johnson ... 104
—— of Sulphur in Pyrite, Results of Co-operative Work on the H. C. Moore 232
—— of Temporary Hardness in Water, Indicators for the J. F. Norton and H. I. Knowles 73
—— of the Hardness of Water, Using Methyl Red as Indicator S. A. Kay and S. H. Newlands ... 49
—— of Tungsten, Rapid Qualitative W. L. Faust 49
Determining Nitrogen in Coal and Coke, Acceleration of Kjeldahl's Method of B. M. Margosches and A. Lang 4
Detonators, Advantages of Stronger ... 116
Development at Niagara Falls, Electric Furnace F. T. Stone 54
Development, The Natal Coalfields—Phases in Wm. Taylor Heslop ... 182
Discussion 227
Devices Used to Regulate the Flow of Oil in the Flotation Process, Some ... 162
Dinwiddie, I. G.—Fluorine in Soluble Fluorides 233
Dissociation Constant of the Acid, The Time Reaction in the Neutralisation of Carbonic Acid and the L. Pusch 140
Distinguished Service 25
—— —— 25, 125, 208
Dolerite on Coal, The Action of 184
Dowling, Remarks by Mr. W. R.—on Proposed Change of Meeting Night... 214
——, ——, —— *on a Shaking Chute for Flat Stopes* 60
Drakeley, T. J.—Influence of Iron Pyrites on the Oxidation of Coal 177
Dressing and Cyaniding, Clay in Ore A. W. Allen 23

PAGE

Drugs from Africa, Solanaceous ... 51
—— and Poisonous Plants, South African ... 103
Durant, H. T.—Refining of Precipitated Gold (Cyanide Process) 23
Dust, Electrolytic Zinc H. J. Morgan O. C. Ralston 162
——, Estimating Metallic Aluminium in Aluminium J. E. Clennell ... 159
—— *Filters, Sugar for R. A. Cooper* 165
Discussion . .. 166, 182

E

Ear Defenders A. J. Herald (Note) ... 81
Discussion 82
Eczema or Rash, Cyanide D. M. Liddell 142
Effect of Ash on Acid Sand in Stope Filling, Neutralisation Chas. Toombs 84
Discussion 87, 135
Do. Reply to 188
—— of Atmospheres Deficient in Oxygen G. A. Burrell and G. G. Oberfell... 201
—— of Clay in Ore Dressing and Cyaniding A. W. Allen 111
Efficiency of Various Amalgams in the Recovery of Gold, The Relative Thomson and Keffer 6
Edmands, H. R.—Solvent Power of Cyanide Solutions 160
Election of New Members 25, 57, 125, 149, 182, 211
—— of Officers and Council, Scrutineers' Report and Declaration of 20
Electrical Shock, Resuscitation after .. 163
Electric Furnace Development at Niagara Falls F. J. Stone 54
—— Furnaces at Salt Lake City .. 144
—— Smelting of Iron in Sweden ... 76
Electro-chemistry in the United States 51
Electrolytic Deposition of Brass A Hönig 176
—— Refining of Copper F. L. Antisell and S. Skowronski . . 145
—— Zine .. . 77, 145
—— —— Dust H. J. Morgan and O. C. Ralston 162
Elements, Atomic Weights of the G. P. Baxter 111
Ellis, R. H.—Potash in Banana Stalks .. 103
Employment as a Preventative of Miner's Phthisis in the Transvaal, Alternative 235
Engine Horse Power at High Altitudes, Computing Gas 55
Equipment at the Bantjes Consolidated Mines, Concrete Shaft W. W. Lawrie and G. Hildick Smith
Reply to Discussion 96
Estimating Metallic Aluminium in Aluminium Dust J. E. Clennell .. 159
Evans, David.—Alloy Steel Castings ... 178
Experiments on a Transvaal Gold Ore, Flotation Concentration F. Wartenweiler 87
Discussion ... 117, 136
do. Reply to .. . 189
—— on the Flotation of Ores, Laboratory C. Y. Clayton 162
Explosions of Fire Damp, and Occurrences of Gob Fires in Natal, Some Notes on J. E. Vaughan and F. E. **Steart** 217
Explosive Gases in Coal Mines, Occurrence of N. H Darton . 162
Explosives, Testing the Strengths of J. J. Campbell 66
Reply to Discussion .. 135
Extraction, Chemical Methods of Tin O. J. Stannard . . . 144
—— of Mercury, Wet E. B. Thornhill 74
—, Pillar 185

F

Fahrenwald, F. A.—Alloy Substitutes for Gold and Platinum 104
Falcon Mine (Rhodesia), Ore Treatment at the H. R. Adam 91
Discussion 94, 95, 96, 118, 137
Reply to Discussion 226
Falls, Electric Furnace Development at F. J. Stone .. 54
Fatal Accidents, Body Chart for Non- A. H. Fay . .. 77
Faust, W. L.—Rapid Qualitative Determination of Tungsten ... 49
Fay A. H.—Body Chart for Non-Fatal Accidents 77
Fellowship System, Five Year's Progress in the Industrial . .. 110
Ferrochromium, The Determination of Chromium in A. F. Macfarland 231
Ferrous Sulphate, Titration of Nitrates with F. C. Bowman and W. W. Scott .. 104
Filters, Sugar for Dust R. A. Cooper 165
Discussion . 166, 182
Fine Grinding . . 52
—— Screens, New 7
Fire Bricks, Testing 142
Firebricks, The Texture of J. W. Mellor 192
Fire Damp, and Occurrences of Gob Fires in Natal, Some Notes on Explosions of J. E. Vaughan and F. E. Steart 217
Firedamp, The Dangers of . 183
Fires, Goaf . 186
First Aid on the Mines T. P. Waites (Note) . . 211
—— Work on the Mines, The Encouragement of A. J. Brett Discussion 45, 97, 98, 99, 100
Reply to Discussion .. 133
Five Years' Progress in the Industrial Fellowship System 110
Flat Stopes, Shaking Chute for S. Nettleton (Note) . 57
Discussion . . . 60
Fleming, J. A.—The Organisation of Scientific Research 78
Floors, A New Remedy for Slippery Iron W. A. Lailer 177
Flotation Concentration Experiments on a Transvaal Gold Ore F. Wartenweiler . 87
Discussion 117, 136
do. Reply to 189
—— Concentrate, Cyanide Treatment of C. Butters and J. E. Clennell 21
—— New Theories of 20
—— of Flour Gold R. W. Smith 143
——, Oils and other Reagents in Ore R. J. Anderson 23
—— ——, Froths Formed by W. A. Mueller . 141

PAGE

Flotation of Ores, Laboratory Experiments on the C. Y. Clayton ... 162
—— Plant ... 92
—— Processes A. F. Taggart and F. E. Beach ... 195
—— Process, Some Devices Used to Regulate the Flow of Oil in the ... 162
—— ——, The Callow Pneumatic Oil J. M. Callow ... 7
—— Test on Antimony Gold Ore E. R. Pilgrim ... 162
——, Use of Oils in H. A. Megraw ... 141
Flour Gold, Flotation of R. W. Smith 143
Flowsheet Showing the Usefulness of the Tube Mill in Stage Grinding ... 22
Fluorine in Soluble Fluorides J. G. Dinwiddie ... 233
Frood, G. E. B.—Cape Asbestos Industry 180
Froths Formed by Flotation Oils W. A. Mueller ... 141
Furnace Development at Niagara Falls, Electric F. J. Stone ... 54
—— Construction, Thermal Conductivity of Materials Employed in E. Griffiths ... 192
——, Tapping Matte from Blast ... 94
Furnaces at Salt Lake City, Electric ... 144
—— in the U.S.A., Heroult ... 145

G

Gaebelein, P. W. Cyaniding Copper Bearing Ores ... 119
Galbreath, Remarks by Mr. N. M.—on Flotation Concentration Experiments on a Transvaal Gold Ore (Discussion) 117
Gascoyne, Remarks by Mr. Rowland.—on the Natal Coalfields—Phases in Development ... 227
Gas Engine Horse Power at High Altitudes, Computing ... 55
Gases in Coal Mines, Occurrence of Explosive N. H. Darton ... 162
Gasoline Standards ... 177
General Meetings, Proceedings at Ordinary
  September 16, 1916 ... 25
  October, 21, 1916 ... 57
  November, 18, 1916 ... 81
  February 17, 1917 125
  March 17, 1917 149
  April 21, 1917 165
  May 19, 1917 181
  June 23, 1917 205
Goaf Fires ... 186
Gob Fires in Natal, Some Notes on Explosions of Fire Damp, and Occurrences of J. E. Vaughan and F. E. Steart... 217
Gold and Platinum, Alloy Substitutes for F. A. Fahrenwald ... 104
—— Bullion (Cyanide), Segregation in J. H. Hance ... 110
—— (Cyanide Process), Refining of Precipitated A. T. Durant ... 23
——, Flotation of Flour R. W. Smith 143
—— in Pebbles ... 181, 214
—— Mines, Alaska ... 114
—— *Ore, Flotation Concentration Experiments on a Transvaal F. Wartenweiler* ... 87
  Discussion ... 117, 136
  do. Reply to ... 189

PAGE

Gold Ore, Flotation Test on Antimony E. R. Pilgrim ... 162
——, The Relative Efficiency of Various Amalgams in the Recovery of Thomson and Keffer ... 6
Gothman, E.—The Sound Ingot Problem .. 22
Government Laboratory of Veterinary Research, Proposed Visit to ... 128
Graham, K. L.—Comparison of Stamp Milling Costs between Californian and Nissen Stamps at Modder B. ... 118
  Discussion ... 128
  do. Reply to ... 176
Grain Size of Metals, Measurement of Z. Jeffries ... 106
Grants, Awards and ... 208
Gray, Remarks by Mr. C. J.—on Explosions of Fire Damp and Occurrences of Gob Fires in Natal ... 226
——, —— —— *on Natal Coalfields—Phases in Development* ... 188
——, —— *by Mr. Jas.—on Election as Councillor* ... 211
——, —— —— *on Sugar for Dust Filters* 166, 182
Griffin Mills ... 54
Griffiths, E. — Thermal Conductivity of Materials Employed in Furnace Construction ... 192
Grinding, Crushing and L. D. Mills and M. H. Kuryla ...
——, Fine ... 52
——, Flow Sheet Showing the Usefulness of the Tube Mill in Stage ... 22
—— Pans ... 54
——, The Year's Changes in Crushing and Algernon del Mar... 21
Grossmann, J.—Utilisation of Nitre Cake... 159
Grothe and Carter. Improvised Stamp Shoes 8
Gutbier, A., J. Huber, E. Kuhn and J. Krauter.—Iceland Moss as a Protective Colloid ... 141
Guareschi, I. Properties of Soda Lime ... 140

H

Haldane, J. S.—The Health of Old Age Colliers ... 55
Hall Process for Removing Sulphur from Ores ... 7
Hance, J. H.—Segregation in Gold Bullion (Cyanide) ... 110
Handling Boilers to Prevent Corrosion and Scale, A Novel Method of A. H. Babcock ... 146
Hand Stoping ... 179
Handy, D. M. Buck and J. O.—Non-Corroding Steel ... 119
Hagmaier, E. W.—Analysis of Babbitt Metal 232
Hardinge Mills at Anaconda F. Laist and A. E. Wiggin.. ... 105
Hardening and Annealing of Metals, The Prof. T. Turner ... 61
  Discussion ... 100
—— High Speed Steel for Machine Tools R. A. Millholland... ... 7
—— of Concrete, Calcium Chloride for Accelerating ... 108
Hardness of Water Using Methyl Red as Indicator, Determination of the S. A. Kay and S. H. Newlands ... 49

PAGE

Hardness in Water, Indicators for the Determination of Temporary J. F. Norton and H. I. Knowles ... 73
Harris, L. J. Curtmann and B. R.—Detection of Thiocyanates ... 232
Haynes, E.—Stellite ... 23
Health and Well-being of Workmen on Witwatersrand Mines ... 120
Health—Natives ... 121
—— of Old Age Colliers, The J. S. Haldane ... 55
Herold, A. J.—Ear Defenders (Note) ... 81
Discussion ... 82
Heroult Furnaces in the U.S.A. ... 145
Heslop, Wm. Taylor.—The Natal Coalfields—Phases in Development ... 182
Discussion ... 227
High Speed Steel for Machine Tools, Hardening R. A. Millholland ... 7
Hoisting of Rock ... 179
Honig, A.—Electrolytic Deposition of Brass 176
Honour, Roll of ... 25, 57, 81, 208
Horse Power at High Altitudes, Computing Gas Engine ... 55
Hours of Work, etc., on Transvaal Mines... 179
Hours, Working ... 122
Huber, J., E. Kuhn and I. Krauter, A. Gutbier.—Iceland Moss as a Protective Colloid ... 141
Hydrocyanic Acid, Determination of Small Quantities of M. O. Johnson . 104
— ——, Investigation of the Chief Methods of Detecting G. Anderson ... 176
Hydrogen, Methods of Technical Preparation of ... 29
——, Uses of ... 30

I

Iceland Moss as a Protective Colloid A. Gutbier, J. Huber, E. Kuhn and J. Krauter ... 141
Importance of Chromium, Growing . 161
Improvised Stamp Shoes Grothe and Carter ... 8
Impurities in Commerical Tin ... 143
Industrial Activities ... 209
—— Fellowship System, Five Years' Progress in the ... 110
—— *Research The President (Note)* ... 82
Industries, Cellulose ... 36
Industry, Alkali ... 33
——, Artificial Perfumery ... 35
——, Bakelite ... 36
——, Cape Asbestos G. E. B. Frood . 180
——, Materials of Construction in Chemical 27
—— of Artificial Medicines . 35
—— of the Per Salts . 34
——, Photographic Chemical ... 35
Indicator, Determination of the Hardness of Water Using Methyl Red as S. A. Kay and S. H. Newlands 49
Indicators for the Determination of Temporary Hardness in Water J. F. Norton and H. I. Knowles 73
Industry, Recent Advances in Chemical Presidential Address Professor J. I. Wilkinson . 27
Influence of Iron Pyrites on the Oxidation of Coal T. J. Drakeley 177
—— of Oxygen on Some Properties of Pure Iron, The T. Swinden 6
Ingot Problem, The Sound E. Gothman 22
Inoculation against Pneumococcal Infection, Prophylactic F. S. Lister .. 204
Investigation of the Chief Methods of Detecting Hydrocyanic Acid G. Anderson .. 176
Iron and Steel Made Rust Proof 147
Iron Floors, A New Remedy for Slippery W. A. Lailer .. 177
—— from Tin Ores, Removing . 178
—— Pyrites on the Oxidation of Coal, Influence of T. J. Drakeley .. 177
—— in Sweden, Electric Smelting of .. 76
——, On the Transformations of Pure A. F. Oxley ... 18
—— *Plates, The Removal of Rust from F. W. Watson* ... 109
——, Thallium, Zirconium and Titanium, Qualitative Separation of Tellurium, Arsenic P. E. Browning, G. S. Simpson and L. E. Porter .. 142
——, The Influence of Oxygen on Some Properties of Pure T. Swinden 6
Irregularity of Markets .. 187

J

Jeffries, Z.—Measurement of Grain Size of of Metals .. 105
Johnson, J. Pratt.—Silicosis in Rats in a Witwatersrand Mine . 150
Discussion ... 155, 156, 157, 1174
——, *Remarks by Mr. A. McArthur on Ear Defenders* ... 82
——, *Reply by Dr. Pratt*... . 157
——, M. O.—Determination of Small Quantities of Hydrocyanic Acid 104
Joint, A New Track and Rail L. W. Moerr 127
Journal, The July, 1916 .. 1
August, 1916 .. 9
September, 1916 25
October, 1916 . 57
November, 1916 . 81
December, 1916 . 109
January, 1917 117
February, 1917 . 125
March, 1917 149
April, 1917 165
May, 1917 . 181
June, 1917 .. 205

K

Kay, S. A. and S. H. Newlands. Determination of the Hardness of Water Using Methyl Red as Indicator 49
Keffer, Thomson and—The Relative Efficiency of Various Amalgams in the Recovery of Gold . 6
Kelley, G. L. A New Absorbent for CO_2 in Steel Analysis 193
Kjeldahl's Method of Determining Nitrogen in Coal and Coke, Acceleration of B. M. Margosches and A. Lang 4
Knowles, I. F. Norton and H. I.—Indicators for the Determination of Temporary Hardness in Water 73
Krauter, A. Gutbier, J. Huber and J.—Iceland Moss as a Protective Colloid 141
Kuryla, L. D. Mills and M. H.—Crushing and Grinding ... 51

L

PAGE

Laboratory Experiments on the Flotation of Ores C. Y. Clayton 162
—— of Veterinary Research, Proposed Visit to Government 128
—— Agitation Vat 76
Labour in Reduction Works 235
—— Saving on the Mines, Time and ... 106
—— —— —— —— Underground Supervision, Time and 116
Lailer, W. A.—A New Remedy for Slippery Iron Floors 177
Laist, F. and A. E. Wiggin.—Hardinge Mills at Anaconda 105
Lake Muds, Potash in 139
Lang, B. M. Margosches and A.—Acceleration of Kjeldahl's Method of Determining Nitrogen in Coal and Coke 4
Lawrie, W. W., and G. Hildick-Smith.—Concrete Shaft Equipment at the Bantjes Consolidated Mines Reply to Discussion 96
Lead Corroding Process, New 191
—— Molybdate H. B. Weisser ... 193
——, Rapid Assay of G. Torossian ... 159
Lehfeldt, Prof. R. A.—The Valuation of Mines 1-4
Discussion ... 38, 135
do. Reply to 158
Le Roy, G. A.—Determination of Free Chlorine in Town Water Supplies... 142
Letter from Capt. G. W. Williams ... 26
Major R. S. G. Stokes 26
Liddell, D. M.—Cyanide Eczema or Rash .. 142
Lime, Properties of Soda I. Guareschi .. 140
Limestone and Ammonium Salts, New Applications of Thymolphthalein and Naphtholphthalein, including Rapid Methods for Analysing J. Moir 129
Discussion 158, 174
— Sulphur Solutions, New Methods for the Analysis of R. M. Chapin 104
—, *The Solubility of A. F. Crosse (Note)* 125
Discussion ... ... ·126
Lind and Schaefer, Parsons, Moore.—Radium from Carnotite 72
Lindsay, Robert.—Notes on Treatment of Pilgrims Rest Ore 166
Discussion 172, 173, 189
Lester, F. S.—Prophylactic Inoculation against Pneumococcal Infection ... 204
List of Papers 208
Lister, Remarks by Dr. F. S.—on Silicosis in Rats in a Witwatersrand Mine ... 156
Lithium from other Alkali Metals, Separation of S. Palkin 193
Little, A. D.—Utilisation of Wood Waste.. 5
Littlejohn, Remarks by Mr. Jas. on Proposed Change of Meeting Night ... 213

M

Macfarland, A. F.—The Determination of Chromium in Ferrochromium . 231
Machine Stoping 179
Machine Tools, Hardening High Speed Steel for R. A. Millholland .. 7
Madagascar, Notes on Rare Minerals in T. P. Waites Discussion 39, 69
Reply to Discussion ... 70
Magnesium and Its Future .. 161

PAGE

Maintenance of Slime Doms, The Construction and J. E. Thomas and E. A. Osterloh 214
Manganese Silver Problem, The Walter Neal (Note) 9-18
Summary 17
Discussion 39, 70
—— Steels 28
Manufacture of Ammonium Sulphate, Methods for Dealing with Arsenical Sulphuric Acid in the P. Parrish 72
Mar, Algernon del.—The Year's Changes in Crushing and Grinding 21
Margosches, B. M. and A. Lang.—Acceleration of Kjeldahl's Method of Determining Nitrogen in Coal and Coke 4
Mark, Remarks by Mr. J. H. on Neutralisation Effect of Ash on Acid Sand in Stope Filling 87
Markets, Irregularity of 187
——, Preparation of Coal for 187
Materials Employed in Furnace Construction, Thermal Conductivity of E. Griffiths 192
—— from South Africa, Paper Making .. 177
—— of Construction in Chemical Industry 27
Matheson, A. M.—Chemical Assay of Tin Ores 143
Matte from Blast Furnace, Tapping 94
Measurement of Grain Size of Metals Z. Jeffries 106
Medicines, Industry of Artificial 35
Meeting Night, Proposed Change of 213
Meetings, Attendance at Council ... 209
——, Procedure at ... 149
——, Proceedings at Ordinary General
September 16, 1916 25
October 21, 1916 57
November 18, 1916 .. 81
February 17, 1917 125
March 17, 1917 149
April 21, 1917 165
May 19, 1917 181
June 23, 1917 205
Megraw, H. A.—Use of Oils in Flotation . 141
Mellor, E. T.—The Conglomerates of the Witwatersrand Reply to Discussion 41
——, —— Gold in Pebbles 214
——, —— The Texture of Firebricks . 192
Melting Points and other Standard Temperatures, United States Bureau of Standards 49
Melvill, Remarks by Mr. G.—on Notes on Treatment of Pilgrims Rest Ore ... 173
Members, Election of New 25, 57, 125, 149, 182, 211
Membership 206
Men and Material, Transport of ... 179
——, Effect on 202
Mercury, Volumetric Determination of G. Adanti 193
——, Wet Extraction of E. B. Thornhill 74
Metal, Analysis of Babbitt E. W. Hagmaier . 232
Metallic Aluminium in Aluminium Dust, Estimating J. E. Clennell .. 159
Metallurgy, Application of X Rays to 104
—— of the Rarer Metals, The J. W. Richards 160

PAGE

Metals Examined by X Rays, Crystal Structure of W. H. Bragg . 115
——, Measurements of Grain Size of Z. Jeffries 106
——, Separation of Lithium from other Alkali S. Palkin 193
——, Surface Tension and Cohesion of S. W. Smith 199
——, *The Hardening and Annealing of Prof. T. Turner* 61
Discussion 100
Method, Determination of Phosphoric Acid by the Citro Uranium D. Crispo and R. W. Tuinzing 141
—— of Zinc Precipitation, A New H. R. Conklin 200
—— of Handling Boilers to Prevent Corrosion and Scale, A Novel A. H. Babcock 146
Methods of Detecting Hydrocyanic Acid, Investigation of the Chief G. Anderson 176
—— of Dealing with Arsenical Sulphuric Acid in the Manufacture of Ammonium Sulphate P. Parrish .. 72
—— for the Analysis of Lime Sulphur Solutions, New R. M. Chapin ... 104
—— of Determining Nitrogen in Coal and Coke, Acceleration of Kjeldahl's B. M. Margosches and A. Lang . 4
—— of Scientific Research 78
—— of Technical Preparation of Hydrogen 29
—— of Tin Extraction, Chemical O. J. Stannard 144
Methyl Red as Indicator, Determination of the Hardness of Water Using S. A. Kay and S. H. Newlands . 49
Meyer, Remarks by Mr. H. S.—on Proposed Change of Meeting Night 213, 214
Mice, Tests with 202
Middleton and H. L. Miller, A. R.—Detection of Nickel in Cobalt Salts .. 192
Miller, A. R. Middleton and H. L.—Detection of Nickel in Cobalt Salts ... 192
Millholland, R. A.— Hardening High Speed Steel for Machine Tools 7
Mill in Stage Grinding, Flow Sheet Showing the Usefulness of the Tube . 22
Milling Data, Stamp 52
—— ——, Tube 53
—— *Costs between Californian and Nissen Stamps at Modder B., Comparison of Stamp K. L. Graham* . 118
Discussion 128
do. Reply to 176
Mills at Anaconda, Hardinge F. Laist and A. E. Wiggin 105
—— and Tube Mills, Stamps, Chilean ... 53
——, Ball 54
——, Griffin . . 54
——, L. D. and M. H. Kuryla, Crushing and Grinding . . 51
Mine Ambulance Competitions . .. 149
—— Cars, Roller Bearings *v.* Plain Bearings on 145
—— Pipes, A Self Cleaning Strainer for.. 8
Minerals in Madagascar, Notes on Rare T. P. Wates Discussion 39, 69
Reply to Discussion 70
Miner's Phthisis in the Transvaal, Alternative Employment as a Preventative of 235
Miners' Phthisis, Prevention of 121
Mines, Alaska Gold ... 114
——, *First Aid on the T. P. Wates (Note)* 211
——, Health and Well-Being of Workmen on Witwatersrand . . 120
——, Hours of Work, etc., on Transvaal 179
——, Occurrence of Explosive Gases in Coal N. H. Darton 162
——, Payment of Wages on Transvaal . 203
——, Security of Tenure on Transvaal . 203
——, *The Valuation of Prof. R. A. Lehfeldt* 14
Discussion .. 38, 135
do. Reply to 158
——, Time and Labour Saving on the 106
——, Underground Supervision, Time and Labour Saving on the ... 116
——, Water Consumption in Westralian 163
——, *The Encouragement of First Aid Work on the A. J. Brett Discussion* .. 45, 97, 98, 99, 100
Reply to Discussion 133
——, The Payment of Overtime on Transvaal 235
Mine (Rhodesia), Ore Treatment at the Falcon H. R. Adam . .. 91
Discussion 94, 95, 96, 118, 137
Reply to Discussion 226
——, *Silicosis in Rats in a Witwatersrand J. Pratt Johnson* 150
Discussion .. 155, 156, 157, 174
Moir, J.—New Applications of Thymolphthalein and Naphtholphthalein, including Rapid Methods for Analysing Limestone and Ammonium Salts 129
Discussion .. . 158, 174
——, *Remarks by Dr. J.—on Neutralisation Effect of Ash on Acid Sand in Stope Filling* 136
——, —— —— *on Presidential Address* .. 37
on Solubility of Lime . 126
Molybdate, Lead H. B. Weisser . 193
Moore, H. C. Results of Co-operative Work on the Determination of Sulphur in Pyrite 232
——, Lind and Schaefer, Parsons.—Radium from Carnotite 72
Morgan and O. C. Ralston, H. J.—Electrolytic Zinc Dust . . 162
Moss as a Protective Colloid, Iceland A. Gutbier, J. Huber, E. Kuhn and J. Kranter 141
Mud, Potash in Lake . 139
Mueller, W. A. Froths Formed by Flotation Oils ... 141

N

Naphtholphthalein, including Rapid Methods for Analysing Limestone and Ammonium Salts, New Applications of Thymolphthalein and J. Moir 129
Discussion 158, 174
Natal Coalfields Phases in Development, The Wm. Taylor Heslop 182
Discussion . 227
Natal, Some Notes on Explosions of Fire Damp and Occurrences of Gob Fires in J. E. Vaughan and F. E. Steart .. 217
Natives, Health— .. . 121

Page

Neal, Walter.—The Manganese Silver Problem 9-18
Summary 17
Discussion 39, 70
Nettleton, S.—Shaking Chute for Flat Stopes (Note) 57
Discussion 60
Neutralisation Effect of Ash on Acid Sand in Stope Filling *Chris. Toombs* 84
Discussion 87, 135
Do. Reply to 188
—— of Carbonic Acid and the Dissociation Constant of the Acid, The Time Reaction in the L. Pusch ... 140
New Applications of Thymolphthalein and Naphtholphthalein, including Rapid Methods for Analysing Limestone and Ammonium Salts *J. Moir* 129
Discussion 158, 174
New Books 71, 158, 180
— Colour Reaction for Aloes C. E. Stacy 118
—— Fine Screens 7
Newlands, J. A. Kay and S. H.—Determination of the Hardness of Water Using Methyl Red as Indicator . 49
— — Lead Corroding Process 191
— Members, Election of 25, 57, 125, 149, 182, 211
Methods for the Analysis of Lime Sulphur Solutions R. M. Chapin 104
— Theories of Flotation .. . 20
Newton, Remarks by Mr. S. on Notes on Treatment of Pilgrims Rest Ore . 173
on Behalf of Scrutineers 211
— *Track and Rail Joint* *L. W. Macer* 127
Niagara Falls, Electric Furnace Development at F. J. Stone 54
Nickel in Cobalt Salts, Detection of A. R. Middleton and H. L. Miller ... 192
Nissen Stamps at Modder B., Comparison of Stamp Milling Costs between Californian and *K. L. Graham* ... 118
Discussion 128
do. Reply to 176
Nitrates with Ferrous Sulphate, Titration of F. C. Bowman and W. W. Scott .. 104
Nitre Cake, Utilisation of J. Grossmann 159
Nitric Nitrogen, Determination of F. M. Scales 231
Nitrogen, Artificial Transformation of . 30
in Coal and Coke, Acceleration of Kjeldahl's Method of Determining B. M. Margosches and A. Lang ... 4
Non-Corroding Steel D. M. Buck and J. O. Handy 119
Norton, J. F. and H. I. Knowles.—Indicators for the Determination of Temporary Hardness in Water . 73
Notes on Explosions of Fire Damp, and Occurrences of Gob Fires in Natal, Some *J. E. Vaughan and F. E. Steart* 217
— *on Rare Minerals in Madagascar* *T. P. Waites* *Discussion* 39, 69
Reply to Discussion . 70
—— *on the Treatment of Pilgrims Rest Ore* Robert Lindsay . .. 166
Discussion . 172, 173, 189

Oberfell, G. A. Burrell and G. G.—Effect of Atmospheres Deficient in Oxygen 201

O

Page

Occurrence of Explosive Gases in Coal Mines N. H. Darton 162
Occurrences of Gob Fires in Natal, Some Notes on Explosions of Fire Damp and *J. E. Vaughan and F. E. Steart* 217
Old Age Colliers, The Health of J. S. Haldane 55
Officers and Council, Scrutineers' Report and Declaration of Election of.. .. 210
Oils and other Reagents in Ore Flotation R. J. Anderson 23
—— in Flotation, Use of H. A. Megraw 141
Oil in the Flotation Process, Some Devices Used to Regulate the Flow of ... 162
—— Flotation Process, The Callow Pneumatic J. M. Callow 7
——, Froths Formed by Flotation W. A. Mueller 141
On the Transformations of Pure Iron A. F. Oxley 18
Ore Dressing and Cyaniding, Clay in A. W. Allen 23
——, *Flotation Concentration Experiments on a Transvaal Gold* *F. Wartenweiler* 87
Discussion .. 117, 136
do. Reply to 1
——, Oils and other Reagents in R. J. Anderson .. 23
—— —— Test on Antimony Gold E. R. Pilgrim 162
Orenstein, Remarks by Dr. A. J.—on the Encouragement of First Aid Work on the Mines 98
Ores, Chemical Assay of Tin A. M Matheson 143
——, Cyaniding Copper Bearing P. W. Gaebelein 119
——, Hall Process for Removing Sulphur from 7
—, Laboratory Experiments on the Flotation of C. Y. Clayton .. 162
——, Removing Iron from Tin . . 178
Ore Treatment at the Falcon Mine (Rhodesia) *H. R. Adam* 91
Discussion 94, 95, 96, 118, 137
Reply to Discussion 226
Organisation of Scientific Research, The J. A. Fleming 78
Osterloh, J. E. Thomas and E. A. The Construction and Maintenance of Slime Dams 214
Overtime on Transvaal Mines, The Payment of 235
Oxidation of Coal, Influence of Iron Pyrites on the T. J. Drakeley .. 177
Oxide, Determination of Aluminium as W. Blum 141
Oxley A. F.—On the Transformations of Pure Iron 18
Oxygen, Effect of Atmospheres Deficient in G. A. Burrell and G. G. Oberfell .. 201
—— on Some Properties of Pure Iron, The Influence of T. Swinden 6

P

Palkin, S.—Separation of Lithium from other Alkali Metals 103
Pans, Grinding 54
Paper Making Materials from South Africa 177

PAGE
Papers, List of . 208
Parrish, P.—Methods for Dealing with Arsenical Sulphuric Acid in the Manufacture of Ammonium Sulphate .. 72
Parsons, Moore, Lind and Schaefer.—Radium from Carnotite 72
Payment of Overtime on Transvaal Mines, The 235
—— of Wages on Transvaal Mines . 203
Pebbles, Gold in 181, 214
Perfumery Industry, Artificial . 35
Per Salts, Industry of the . . 34
Perley, G. A. and C. W. Davis.—Regeneration of Sulphated Storage Cells 109
Pfenniger, E. Bosshard and R.—Corrosion of Boilers 72
Phases in Development, The Natal Coalfields— Wm. Taylor Heslop . 182
Discussion 227
Phosphoric Acid by the Citro Uranium Method, Determination of D. Crispo and R. W. Tuinzing 141
Photographic Chemical Industry ... 35
Phthisis in the Transvaal, Alternative Employment as a Preventative of Miner's 235
——, Prevention of Miners' 121
Pilgrim, E. R.—Flotation Test on Antimony Gold Ore .. . 162
Pilgrims Rest Ore, Notes on Treatment of Robert Lindsay 166
Discussion . 172, 173, 189
Pillar Extraction 185
Pipes, A Self Cleaning Stainer for Mine .. 8
Plain Bearings on Mine Cars, Roller Bearings *v.* 145
Plant, Flotation 92
——, Sintering 93
Plants, South African Drugs and Poisonous 103
Plates, The Removal of Rust from Iron F. W. Watson 109
Platinum, Alloy Substitutes for Gold and F. A. Fahrenwald 104
Pneumatic Oil Flotation Process, The Callow J. M. Callow 7
Points and other Standard Temperatures, Melting, United States Bureau of Standards ... 49
Poisonous Plants, South African Drugs and 103
Porter, P. E. Browning, G. S. Simpson and L. E.—Qualitative Separation of Tellurium, Arsenic, Iron, Thallium, Zirconium and Titanium . . 142
Portland Cement G. A. Rankin . 140
Potash, American Production of . 73
—— in Banana Stalks R. H. Ellis . 103
—— in Lake Muds 139
Potassium Bichromate as an Analytical Standard I. G. Bruhns . 109
Pouring Blister Copper . 95
Power at High Altitudes, Computing Gas Engine Horse 55
Powers of the World, Water D. B. Rushmore .. 146
Pratolongo, N.—Technological Chemical Research on Superphosphates . 191
Precipitated Gold (Cyanide Process), Refining of H. T. Durant .. 23
Precipitation, A New Method of Zinc H. R. Conklin . . 200
Preparation of Coal for Markets . 187
—— of Hydrogen, Methods of Technical 29
President (Prof. J. A. Wilkinson), Remarks by the on Annual Report .. 210
——, on Attendance at Meetings 189
——, on Distinguished Service 25
——, *on the Encouragement of First Aid Work on the Mines Discussion* 45 99
——, on First Aid on the Mines .. . 212
——, on Flotation Concentration Experiments on a Transvaal Gold Ore 90, 137
——, on the Hardening and Annealing of Metals 66
——, on Industrial Research . 82
——, on Invitations to Members . 61
——, on Letters from Overseas . 26
——, on Members Honoured . 125
——, on Mine Ambulance Competitions 149
——, on Natal Coalfields—Phases in Development 188
——, on Neutralisation Effect of Ash on Acid Sand in Stope Filling .. 87
——, on New Applications of Thymolphthalein and Naphtholphthalein 132, 158
——, on Notes on Rare Minerals in Madagascar (Discussion) .. 39, 69
——, on Notes on Treatment of Pilgrims Rest Ore 173
——, on Ore Treatment at the Falcon Mine (Rhodesia) . .. 94, 95
——, on the Past and Future of the Society 229
——, on Proposed Change of Meeting Night 213
——, on Roll of Honour . 25, 57, 81
——, on Scientific and Technical Committee 149
——, on Scrutineers' Report and Declaration of New Officers 210
——, on a Shaking Chute for Flat Stopes . 60
——, on Silicosis in Rats in a Witwatersrand Mine . . 155
——, on Solubility of Lime .. 126
——, on Sugar for Dust Filters . . 166
——, on Testing the Strength of Explosives 69
——, on Underground Ambulance Shield Competition 165
——, on Visit to Chandler's Brewery .. 181
——, on Vote of Thanks for Address 37
——, on Winners of the Society's Prizes . 128
Presidential Address, Recent Advances in Chemical Industry Professor J. A. Wilkinson . . . 27
Preventative of Miner's Phthisis in the Transvaal, Alternative Employment as a . 235
Prevent Corrosion and Scale, A Novel Method of Handling Boilers to A. H. Babcock . 146
Prevention of Corrosion, The 110
—— of Miners' Phthisis 121
Primary Crushing 51
Prizes, Winners of Society's . 128
Problem, The Manganese Silver Walter Neal . 9, 18
Summary 17
Discussion 39, 70
——, The Sound Ingot E. Gothman 22
Procedure at Meetings . 149
Proceedings at Ordinary General Meetings
September 16, 1916 25
October 21, 1916 57
November 18, 1916 81
February 17, 1917 125
March 17, 1917 . 149
April 21, 1917 165
May 19, 1917 181
June 32, 1917 . 205

PAGE

Processes, Flotation A. F. Taggart and F. E. Beach 195
Process, New Lead Corroding 191
——, The Bisulphate Zinc 233
——, The Callow Pneumatic Oil Flotation F. M. Callow 7
—— for Removing Sulphur from Ores, Hall 7
Production of Potash, American 73
Progress in the Industrial Fellowship System, Five Year's 110
Proof, Iron and Steel Made Rust 147
Properties of Pure Iron, The Influence of Oxygen on Some T. Swinden 6
—— of Soda Lime I. Guareschi 140
Prophylactic Inoculation against Pneumococcal Infection F. S. Lister 204
Proposed Change of Meeting Night 213
—— Visit to Government Laboratory of Veterinary Research 128
Protective Colloid, Iceland Moss as a A. Gutbier, J. Huber, E. Kuhn and J. Kranter 141
Provision of Means for Conducting Scientific Research 79
Pure Iron, On the Transformation of A F. Oxley 18
—— ——, The Influence of Oxygen on Some Properties of T. Swinden 6
Pusch, L.—The Time Reaction in the Neutralisation of Carbonic Acid and the Dissociation Constant of the Acid 140
Pyrites on the Oxidation of Coal, Influence of Iron T. J. Drakeley 177
Pyrite, Results of Co-operative Work on the Determination of Sulphur in H. C. Moore 232

Q

Qualitative Determination of Tungsten, Rapid W. L. Faust 49
—— Separation of Tellurium, Arsenic, Iron, Thallium, Zirconium and Titanium P. E. Browning, G. S. Simpson and L. E. Porter 142

R

Radium from Carnotite Parsons, Moore, Lind and Schaefer 72
Rail Joint, A New Track and L. W. Macer (Note) 127
Ralston, H. J. Morgan and O. C.—Electrolytic Zinc Dust 162
Rankin, G. A.—Portland Cement 140
Rapid Assay of Lead G. Torossian 159
—— Qualitative Determination of Tungsten W. L. Faust 49
Rare Minerals in Madagascar, Notes on T. P. Waites Discussion 39, 69
Reply to Discussion 70
Rarer Metals, The Metallurgy of the J. W. Richards 160
Rash, Cyanide Eczema or D. M. Liddell 142
Rats in a Witwatersrand Mine, Silicosis in J. Pratt Johnson 150
Discussion 155, 156, 157, 174
Rays to Metallurgy, Application of X 104
Reagents in Ore Flotation, Oils and other R. J. Anderson 23
Reaction for Aloes, New Colour C. E. Stacy 118

PAGE

Reaction in the Neutralisation of Carbonic Acid and the Dissociation Constant of the Acid, The Time L. Pusch 140
Recent Advances in Chemical Industry Prof. J. A. Wilkinson (Presidential Address) 27
Recovery of Gold, The Relative Efficiency of Various Amalgams in the Thomson and Keffer 6
Red as Indicator, Determination of the Hardness of Water Using Methyl S. A. Kay and S. H. Newlands 49
—— Cross Society, South African 208
Reduction Works, Labour in 235
Refining of Copper, Electrolytic F. L. Antisell and S. Skowronski 145
—— of Precipitated Gold (Cyanide Process) H. T. Durant 23
Refractories, Thermal Conductivity of 73
Regeneration of Sulphated Storage Cells G. A. Perley and C. W. Davis 109
Regulate the Flow of Oil in the Flotation Process, Some Devices Used to 162
Regulations, Assayers' Certificates 190
Removal of Rust from Iron Plates F. W. Watson (Note) 109
Remedy for Slippery Floors W. A. Lailer 177
Removing Iron from Tin Ores 178
Removing Sulphur from Ores, Hall Process for 7
Report and Declaration of Election of Officers and Council, Scrutineers' 210
—— of Council, Annual 205
Research, Department of Scientific and Technical 147
——, *Industrial The President (Note)* 82
——, Methods of Scientific 78
——, Provision of Means for Conducting Scientific 79
——, Training of Men Necessary for Conducting Scientific 80
—— on Superphosphates, Technological Chemical N. Pratolongo 191
——, Proposed Visit to Government Laboratory of Veterinary 128
——, The Organisation of Scientific J. A. Fleming 78
Results of Co-operative Work on the Determination of Sulphur in Pyrite H. C. Moore 232
Resuscitation after Electrical Shock 163
Reviews, Book 71, 230
Rhodesia, Ore Treatment at the Falcon Mine H. R. Adam 91
Discussion 91, 95, 96, 118, 137
do. Reply to 226
Richards, J. W.—The Metallurgy of the Rarer Metals 160
Rock Crushing Tests, Standardising M K. Rodgers 112
—— —— J. W. Bell 197
Rodgers, M. K. — Standardising Rock Crushing Tests
Rock, Hoisting of 179
Roller Bearings *v.* Plain Bearings on Mine Cars 145
Roll of Honour 25, 57, 81, 208
Rushmore, D. B.—Water Powers of the World 146
Rust from Iron Plates, The Removal of F. W. Watson 109

PAGE

Rust Proof, Iron and Steel Made ... 147

S

Safety Trolley Wire Box .. 55
Salt Lake City, Electric Furnaces at 144
Salts, Detection of Nickel in Cobalt A. R. Middleton and H. L. Miller .. 192
——, Industry of the Per 34
Sand in Stope Filling, Neutralisation Effect of Ash on Acid Chris. Toombs 84
Discussion 87, 135
Do. Reply to 188
Saving on the Mines, Time and Labour ... 106
Scale, A Novel Method of Handling Boilers to Prevent Corrosion and A. H. Babcock 146
——, Standard Screen 113
Scales, F. M.—Determination of Nitric Nitrogen 231
Scientific and Technical Committee ... 149
—— —— Technical Research, Department of 147
—— ——, Methods of 78
—— ——, Provision of Means for Conducting 79
—— ——, Training of Men Necessary for Conducting 80
—— ——, The Organisation of J. A. Fleming 78
Schaefer, Parsons, Moore, Lind and.—Radium from Carnotite 72
Scott, F. C. Bowman and W. W.—Titration of Nitrates with Ferrous Sulphate 104
Screens, New Fine 7
—— Scale, Standard 113
Scrutineer's Report and Declaration of Election of Officers and Council ... 210
Security of Tenure on Transvaal Mines ... 203
Segregation in Gold Bullion (Cyanide) J. H. Hance 110
Scleroscope Testing Apparatus, The Shore 101
——, The Shore 101
Secretary (Mr. F. Rowland), Remarks by the—on Accounts for Year ... 209
——,—— on Annual General Meeting ... 181
——, —— on Appeal for Comforts ... 26
——,—— on Invitations to Members ... 60
Separation of Lithium from other Alkali Metals S. Palkin 193
—— of Tellurium, Arsenic, Iron, Thallium, Zirconium and Titanium, Qualitative P. E. Browning, G. S. Simpson and L. E. Porter 142
Service, Distinguished 25, 125, 208
Shaft Equipment at the Bantjes Consolidated Mines, Concrete W. W. Lawrie and G. Hildick-Smith Reply to Discussion 96
Shafts, Thermit Welding of Cam 75
Shaking Chute for Flat Stopes S. Nettleton (Note) 57
Discussion 60
Shield Competition, Underground Ambulance 165
Shock, Resuscitation after Electrical ... 163
Shoes, Improvised Stamp Grothe and Carter 8
Shovelling, Trimming and 179
Silicosis in Rats in a Witwatersrand Mine J. Pratt Johnson 150
Discussion ... 155, 156, 157, 174

PAGE

Silver Problem, The Manganese Walter Neal (Note) 9-18
Summary .. . 17
Discussion .. 39, 70
Simpson and L. E. Porter, P. E. Browning, G. S.—Qualitative Separation of Tellurium, Arsenic, Iron, Thallium, Zirconium and Titanium ... 142
Sintering Plant 93
Size of Metals, Measurement of Grain Z. Jeffries 106
Skowronski, F. L. Antisell and S.—Electrolytic Refining of Copper 145
Slime Agitator 145
—— *Dams, The Construction and Maintenance of J. E. Thomas and E. A. Osterloh* 214
Slippery Iron Floors, A Remedy for W. A. Lailer 177
Smelting of Iron in Sweden, Electric .. 76
Smith, Remarks by Mr. G. Hildick—on Election as President 210
——,—— —— on the Encouragement of First Aid Work on the Mines (Discussion) 97
——, —— —— on Explosions of Fire Damp and Occurrences of Gob Fires in Natal 225
——, —— —— on First Aid on the Mines 212
——, —— —— on Invitation to Bantjes Consolidated Mines Central Shaft 84
——, —— —— on Procedure at Meetings .. 149
——, —— —— on Proposed Change of Meeting Night 213, 214
——, —— —— *Reply to Discussion on Concrete Shaft Equipment at the Bantjes Consolidated Mines* ... 96
——, —— —— on Silicosis in Rats in a Witwatersrand Mine 155, 157
——, R. W.—Flotation of Flour Gold ... 143
——, S. W.—Surface Tension and Cohesion of Metals 199
——, *W. W. Lawrie and G. Hildick—Concrete Shaft Equipment at the Bantjes Consolidated Mines Reply to Discussion* 96
Social Status—Better Accommodation ... 123
Society, South African Red Cross 208
Society's Prizes, Winners of 128
Soda Lime, Properties of I. Guareschi... 140
Solanaceous Drugs from Africa 51
Solubility of Lime, The A. F. Crosse 125
Discussion 126
Soluble Fluorides, Fluorine in J. G. Dinwiddie 233
Solutions, New Methods for the Analysis of Lime Sulphur R. M. Chapin... 104
——, Warming Cyanide E. A. Wraight 22
Solvent Power of Cyanide Solutions H. R. Edmands 160
Some Devices Used to Regulate the Flow of Oil in the Flotation Process ... 162
—— *Notes on Explosions of Fire Damp, and Occurrences of Gob Fires in Natal J. E. Vaughan and F. E. Steart...* 217
Sound Ingot Problem, The E. Gothman 22
South African Drugs and Poisonous Plants 103
—— —— Red Cross Society 208
—— Africa, Paper Making Materials from 177
Stacy, C. E.—New Colour Reaction for Aloes 118

PAGE
Stage Grinding.—Flow Sheet Showing the Usefulness of the Tube Mill in ... 22
Stainless Steel ... 77
Stalks, Potash in Banana R. H. Ellis... 103
Stamp Milling Costs between Californian and Nissen Stamps at Modder B., Comparison of K. L. Graham... 118
Discussion ... 128
do. Reply to ... 176
—— —— Data ... 52
Stamps, Chilean Mills and Tube Mills ... 53
—— Shoes, Improvised Grothe and Carter ... 8
Standardising Rock Crushing Tests M. K. Rodgers ... 112
Stannard, O. J.—Chemical Methods of Tin Extraction ... 144
Standard, Potassium Bichromate as an Analytical I. G. Bruhns ... 109
—— Screen Scale ... 113
—— Standards, Gasoline ... 177
—— Temperatures, Melting Points and other United States Bureau of Standards 49
Stanley, Remarks by Prof. G. H.—on Flotation Concentration Experiments on a Transvaal Gold Ore ... 90
——, —— —— on the Hardening and Annealing of Metals ... 66, 100, 101
——, —— —— on Ore Treatment at the Falcon Mine (Rhodesia) ... 95
——, —— —— on Testing the Strength of Explosives ... 69
Stansfield, Dr.—Zinc in Canada ... 5
Status—Better Accommodation, Social ... 123
Steart, J. E. Vaughan and F. E.—Some Notes on Explosions of Fire Damp and Occurrences of Gob Fires in Natal ... 217
Steel Analysis, A New Absorbent for CO_2 in G. L. Kelley ... 193
—— Castings, Alloy David Evans ... 178
—— for Machine Tools, Hardening High Speed R. A. Millholland ... 7
—— Made Rust Proof, Iron and ... 147
——, Non-Corroding D. M. Buck and J. O. Handy ... 119
——, Stainless ... 77
Steels, Manganese ... 28
Stellite E. Haynes ... 23
Stokes, Letter from Major R. S. G. ... 26
Stone, F. J.—Electric Furnace Development at Niagara Falls ... 54
Stope Filling, Neutralisation Effect of Ash on Acid Sand in Chris. Toombs 84
Discussion ... 87, 135
do. Reply to ... 188
Stopes and R. V. Wheeler, M. C.—The Structure of Coal ... 177
Stopes, Shaking Chute for Flat S. Nettleton (Note) ... 57
Discussion ... 60
Stoping, Machine ... 179
Storage Cells, Regeneration of Sulphated G. A. Perley and C. W. Davis ... 109
Strainer for Mine Pipes, A Self Cleaning... 8
Strengths of Explosives, Testing the J. A. Campbell ... 66
Structure of Coal, The M. C. Stopes and R. V. Wheeler ... 177
—— of Metals Examined by X Rays, Crystal W. H. Bragg ... 115
Substitutes for Gold and Platinum Alloy F. A. Fahrenwald ... 104
Sugar for Dust Filters R. J. Cooper (Note) ... 165
Discussion ... 166, 182
Sulphur Solutions, New Methods for the Analysis of Lime R. M. Chapin 104
—— from Ores, Hall Process for Removing 7
Sulphate, Titration of Nitrates with Ferrous F. C. Bowman and W. W. Scott ... 104
Sulphuric Acid in the Manufacture of Ammonium Sulphate, Methods for Dealing with Arsenical P. Parrish ... 72
Sulphated Storage Cells, Regeneration of G. A. Perley and C. W. Davis ... 109
Sulphur in Pyrite, Results of Co-operative Work on the Determination of H. C. Moore ... 232
Superphosphates, Technological Chemical Research on N. Pratolongo ... 191
Supervision, Time and Labour Saving on the Mines—Underground ... 116
Supplies, Determination of Free Chlorine in Town Water G. A. Le Roy ... 142
Surface Combustion ... 108
—— Tension and Cohesion of Metals S. W. Smith ... 199
Suspension and Cancellation of Certificates 191
Sweden, Electric Smelting of Iron in ... 76
Swinden, T.—The Influence of Oxygen on Some Properties of Pure Iron ... 6
System, Five Year's Progress in the Industrial Fellowship ... 110

T

Taggart and F. E. Beach, A. F.—Flotation Processes ... 195
Tapping Matte from Blast Furnaces ... 94
Technical Committee, Scientific and ... 149
—— Preparation of Hydrogen, Methods of 29
—— Research, Department of Scientific and 147
Technological Chemical Research on Superphosphates N. Pratolongo ... 191
Tellurium, Arsenic, Iron, Thallium, Zirconium, and Titanium, Qualitative Separation of P. E. Browning, G. S. Simpson and L. E. Porter ... 142
Temperatures, Melting Points and other Standard United States Bureau of Standards ... 49
Temporary Hardness in Water, Indicators for the Determination of J. F. Norton and H. I. Knowles ... 73
Tension and Cohesion of Metals, Surface S. W. Smith ... 199
Tenure on Transvaal Mines, Security of ... 203
Testing Apparatus, The Shore Scleroscope 101
—— Fire Bricks ... 142
Testing the Strengths of Explosives J. A. Campbell ... 66
Reply to Discussion ... 135
Test on Antimony Gold Ore, Flotation E. R. Pilgrim ... 162
Tests, Standardising Rock Crushing M. K. Rodgers ... 112
—— with Canaries ... 201
—— with Mice ... 202
Texture of Firebricks, The J. W. Mellor ... 192

PAGE

Thallium, Zirconium and Titanium, Qualitative Separation of Tellurium, Arsenic, Iron P. E. Browning, G. S. Simpson and L. E. Porter... 142
The Action of Dolerite on Coal 184
—— Bisulphate Zinc Process 233
—— Callow Pneumatic Oil Flotation Process J. M. Callow 7
—— *Conglomerates of the Witwatersrand E. T. Mellor Reply to Discussion* 41
—— *Construction and Maintenance of Slime Dams J. E. Thomas and E. A. Osterloh* 214
—— Dangers of Firedamp 183
—— Determination of Chromium in Ferrochrominm A. F. Macfarland ... 231
—— *Encouragement of First Aid Work on the Mines A. T. Brett Discussion* ... 45, 97, 98, 99, 100
Reply to Discussion 133
—— *Hardening and Annealing of Metals Prof. T. Turner* 61
Discussion 100
—— Health of Old Age Colliers J. S. Haldane 55
—— Influence of Oxygen on Some Properties of Pure Iron T. Swinden ... 6
—— *Manganese Silver Problem W. Neal* 9-18
Summary 17
Discussion 39, 70
—— Metallurgy of the Rarer Metals J. W. Richards 160
—— *Natal Coalfields—Phases in Development Wm. Taylor Heslop* ... 132
Discussion 227
—— Organisation of Scientific Research J. A. Fleming 78
Theories of Flotation, New 20
The Payment of Overtime on Transvaal Mines 235
—— Prevention of Corrosion 110
—— Relative Efficiency of Various Amalgams in the Recovery of Gold Thomson and Keffer 6
Thermal Conductivity of Materials Employed in Furnace Construction E. Griffiths 192
—— —— of Refractories 73
Thermaline 231
Thermit Welding of Cam Shafts 75
The Shore Scleroscope 101
—— —— —— Testing Apparatus ... 101
—— *Solubility of Lime A. F. Crosse* ... 125
Discussion 126
—— Sound Ingot Problem E. Gothman 22
—— Structure of Coal M. C. Stopes and R. V. Wheeler 177
—— Texture of Firebricks J. M. Mellor 192
—— Time Reaction in the Neutralisation of Carbonic Acid and the Dissociation Constant of the Acid L Pusch 140
—— *Valuation of Mines Prof R. A. Lehfeldt* 1-4
Discussion 38, 135
do. Reply to 158
—— Winning of Coal 185
—— Year's Changes in Crushing and Grinding Algernon del Mar 21
Thiocyanates, Detection of L. J Curtman and B. R. Harris 232

PAGE

Thomas and E. A. Osterloh, J. E. The Construction and Maintenance of Slime Dams 214
——, Remarks by Mr. J. E. on Ear Defenders 82
——, —— — on Notes on Treatment of Pilgrims Rest Ore 173
—, — — on Proposed Change of Meeting Night 243
——, - —— on a Shaking Chute for Flat Stopes 60
Thomson and Keffer.—The Relative Efficiency of Various Amalgams in the Recovery of Gold ... ...
Thornhill, E. B.—Wet Extraction of Mercury 74
Thymolphthalein and Naphtholphthalein, including Rapid Methods of Analysing Limestone and Ammonium Salts New Applications of J. Moir .. 129
Discussion 158, 174
Time and Labour Saving on the Mines ... 106
—— —— —— —— Underground Supervision 16
Tin Extraction, Chemical Methods of O. J. Stannard 144
——, Impurities in Commercial ... 143
—— Ores, Chemical Assay of A. M. Matheson 143
— ——, Removing Iron from 178
Titanium, Qualitative Separation of Tellurium, Arsenic, Iron, Thallium, Zirconium and P. E. Browning, G. S. Simpson and L. E. Porter ... 142
Titration of Nitrates with Ferrous Sulphate F. C. Bowman and W. W. Scott . 104
Toombs, Chris.—Neutralisation Effect of Ash on Acid Sand in Stope Filling . 84
Discussion 87, 135
do. Reply to 188
Track and Rail Joint, A New L. W. Macer (Note) 127
Training of New Men Necessary for Conducting Scientific Research ... 80
Tramming and Shovelling 179
Transformation of Nitrogen, Artificial .. 30
Transformations of Pure Iron, On the A. F. Oxley 18
Transport of Men and Material 179
Transvaal, Alternative Employment as a Preventative of Miner's Phthisis in the 235
—— *Gold Ore, Flotation Concentration Experiments on a F. Wartenweiler* 87
Discussion 117, 136
do. Reply to 189
—— Mines, Hours of Work, etc., on . 179
—— ——, Payment of Wages on ... 203
—— ——, Security of Tenure on .. 203
—— ——, The Payment of Overtime on . 235
Treatment at the Falcon Mine (Rhodesia) Ore H. R. Adam 91
Discussion 94, 95, 96, 118, 137
do. Reply to 226
—— of Flotation Concentrate, Cyanide C. Butters and J. E. Clennell ... 21
—— *of Pilgrims Rest Ore, Notes on Robert Lindsay* .. 166
Discussion ... 172, 173, 189
Trolley Wire Box, Safety .. 55
Tonamy, C. H.- Detection of Blowholes in Castings by X Rays 75

PAGE
Tools, Hardening High Speed Steel, for Machine R. A. Millholland ... 7
Torossian, G.—Rapid Assay of Lead ... 159
Town Water Supplies, Determination of Free Chlorine in G. A. Le Roy ... 142
Tube Milling Data 53
—— Mill in Stage Grinding, Flow Sheet Showing the Usefulness of the ... 22
—— Mills, Stamps, Chilean Mills and ... 53
Tuinzing, D. Crispo and R. W.—Determination of Phosphoric Acid by the Citro Uranium Method 141
Tungsten, Rapid Qualitative Determination of W. L. Faust 49
Turbadium Bronze, Analysis of H. Williams 7
Turbo Air Compressors, Advantages of 146
Turner, Prof. T.—The Hardening and Annealing of Metals 61
Discussion 100

U

Underground Ambulance Shield Competition 165
—— Supervision, Time and Labour Saving on the Mines— 116
United States Bureau of Standards.—Melting Points and other Standard Temperatures 49
—— ——, Electro-chemistry in the .. 51
Uranium Method, Determination of Phosphoric Acid by the Citro D. Crispo and R. W. Tuinzing 141
U.S.A., Heroult Furnaces in the 145
Usefulness of the Tube Mill in Stage Grinding, Flowsheet Showing the ... 22
Use of Oils in Flotation H. A. Megraw 141
Uses of Hydrogen ... .330
Utilisation of Nitre Cake J. Grossmann 159
—— of Wood Waste A. D. Little ... 5

V

Valuation of Mines, The Prof. R. A. Lehfeldt 1-4
Discussion 38, 135
do. Reply to 158
Vat, Laboratory Agitation 76
Vaughan and F. E. Steart, J. E.—Some Notes on Explosions of Fire Damp, and Occurrences of Gob Fires in Natal 217
Veterinary Research, Proposed Visit to Government Laboratory of ... 128
Visits 208
—— to Chandler's Brewery 181
Volumetric Determination of Mercury G. Adanti 193

W

Wages on Transvaal Mines, Payment of ... 203
Waites, Remarks by Mr. T. P.—on the Encouragement of First Aid on the Mines 99, 100
——, *T. P.—First Aid on the Mines* ... 211
——,——, *Notes on Rare Minerals in Madagascar Discussion* ... 39, 69
Reply to Discussion 70
Warming Cyanide Solutions E. A. Wraight 22
Wartenweiler, F.—Flotation Concentration Experiments on a Transvaal Gold Ore 87
Discussion 117, 136
do. Reply to 189
—, Remarks by Mr. F.—on Ear Defenders 82
——, —— —— on the Manganese Silver Problem (Discussion) 70
——, —— —— on Notes on Treatment of Pilgrims Rest Ore 189
Waste, Utilisation of Wood A. D. Little 5
Water Consumption in Westralian Mines ... 163
——, Indicators for the Determination of Temporary Hardness in J. F. Norton and H. I. Knowles .. 73
—— Powers of the World D. B. Rushmore 146
—— Supplies, Determination of Free Chlorine in Town G. A. Le Roy ... 142
—— Using Methyl Red as Indicator, Determination of the Hardness of S. A. Kay and S. H. Newlands ... 19
Watson Remarks by Mr. F. W.—on Neutralisation Effect of Ash on Acid Sand in Stope Filling (Discussion) 135
——, *F. W.—The Removal of Rust from Iron Plates* 103
——, Remarks by Mr. John—on Neutralisation Effect of Ash on Acid Sand in Stope Filling 87
——, —— —— on New Applications of Thymolphthalein and Naphtholphthalein 158
——, —— —— on Solubility of Lime ... 126
Watt, Remarks by Dr. A. H.—on Silicosis in Rats in a Witwatersrand Mine .. 156
Weights of the Elements, Atomic G. P. Baxter 111
Weisser, H. B.—Lead Molybdate 193
Welding of Cam Shafts, Thermit 75
Weston, Remarks by Mr. E. M.—on New Track and Rail Joint 128
——, —— —— on Proposed Change of Meeting Night 213
——, —— —— on the Valuation of Mines (Discussion) 134
Westralian Mines, Water Consumption in .. 163
Wet Extraction of Mercury E. B. Thornhill 74
Wheeler, M. C. Stopes and R. V.—The Structure of Coal 177
Whitby, Remarks by Mr. A.—on Scarcity of Lime 126
White, Remarks by Mr. H. A.—on Comparison of Stamp Milling Costs ... 128
——, —— —— on the Construction and Maintenance of Slime Dams ... 217
——, —— —— on Election as Vice-President 210
——, —— —— on Flotation Concentration Experiments on a Transvaal Gold Ore 90, 137
——, —— —— on the Hardening and Annealing of Metals 65
——, —— —— on Industrial Research ... 84
——, —— —— on the Manganese Silver Problem (Discussion) 39
——, —— —— on Presidential Address ... 37
——, —— —— on Proposed Change of Meeting Night 213
——, —— —— on Scientific and Technical Committee 150

PAGE

White, Remarks by Mr. H A on the Solubility of Lime . 125
——, —— —— on Notes on Treatment of Pilgrims Rest Ore 172
——, —— —— on the Valuation of Mines (Discussion) 38
Wiggin, F. Laist and A. E.—Hardinge Mills at Anaconda 105
Wilkinson, Prof. J. A.—Presidential Address—Recent Advances in Chemical Industry 27
Williams, H. Analysis of Turbadium Bronze 7
——, Letter from Capt. G. W. .. 26
Winners of Society's Prizes .. 128
Winning of Coal, The .. 185
Wire Box, Safety Trolley 55
Withey, W. H.—Analysis of Aluminium and its Alloys 4
Witwatersrand Mines, Health and Wellbeing of Workmen on . 120
— *Mine, Silicosis in Rats in a J. Pratt Johnson* .. . 150
Discussion .. 155, 156, 157, 174
—, *The Conglomerates of the E. T. Mellor Reply to Discussion* ... 41
Wood Waste, Utilisation of A. D. Little 5
Woodburn, Remarks by Mr. J. A on Ore Treatment at the Falcon Mine (Rhodesia) . 95, 137
Work, etc., on Transvaal Mines, Hours of 179
Working Hours 122

PAGE

Workmen on Witwatersrand Mines, Health and Well-being of . 120
Works, Labour in Reduction 235
World, Water Powers of the D. B. Rushmore . 146
Wraight, E. A—Warming Cyanide Solutions . . . 22

X

X Rays, Crystal Structure of Metals Examined by W. H Bragg 115
—— —, Detection of Blowholes in Castings by C. H. Tonamy . 75
—— —— to Metallurgy, Application of 104

Y

Year's Changes in Crushing and Grinding, The Algernon del Mar 21

Z

Zinc Dust, Electrolytic H. J. Morgan and O. C. Ralston 162
—, Electrolytic . . 77, 115
—— in Canada Dr. Stansfield . 5
—— Precipitation, A New Method of H R. Conklin 200
—— Process, The Bisulphate .. 233
Zirconium and Titanium, Qualitative Separation of Tellurium, Arsenic, Iron, Thallium P. E. Browning, G. S. Simpson and L. E. Porter 142

THE JOURNAL

OF THE

CHEMICAL, METALLURGICAL & MINING SOCIETY

OF SOUTH AFRICA.

VOLUME XVIII.

JULY, 1917—JUNE 1918.

JOHANNESBURG.
Published by the Society: Old Municipal Buildings, De Villiers Street.

CONTENTS OF VOLUME XVIII.

Page

Papers and Notes Read before the Society ... v.

Officers and Council of the Society ... vii.

Journal No. 1.—July, 1917 ... 1

" " 2.—August, " ... 31

" " 3.—September " ... 55

" " 4.—October, " ... 95

" " 5.—November, " ... 119

" " 6.—December " ... 147

" " 7.—January, 1918 ... 161

" " 8.—February, " ... 173

" " 9.—March, " ... 197

" " 10.—April, " ... 229

" " 11.—May, " ... 253

" " 12.—June, " ... 285

Index to *Journal* ... 313

PAPERS AND NOTES READ BEFORE THE SOCIETY.

Assay Economics, by Chris. Toombs, 220-222; Discussion, 233-236; ... 253-254

Assay Requisites, by John Watson, 222-223; Discussion, 233-236; ... 253-254

Calculator, A Logarithmic, by D. R. Robinson, 60-62; Discussion, 186; Reply to Discussion ... 219-220

Cementation Process Applied to Mining, The. (François System), by A. H. Krynauw, 256-265; Discussion, 265-268; ... 305

Copper, A New Method of Determining, by Dr. James Moir, 133-135; Discussion, 135, 270-271; Reply to Discussion ... 303

Cyanide and Zinc Consumption, A method for further reducing, by R. C. H. Cooke, 33-36; Discussion, 111-112; ... 185-186

Dust in Mine Air, The Estimation of Injurious, by the Kotzé Konimeter, by John Innes, 199-206; Discussion, 206-216; 243-246; 271-279; ... 304

Fertilizers, by A. Baguley, 121-128; Discussion, 128-133; 149-152; 187-188; Reply to Discussion ... 301-303

Furnace as an Adjunct to the Smithy on a Gold Mine, The, by R. Craib, 254-255; Discussion, 255-256; ... 291-292

Gold Absorption by Copper Amalgamation Plates, by F. Wartenweiler, ... 246-247

Mercury, by Dr. W. A. Caldecott, 162-163; Discussion, 173-180; 197-198; 232-233; Reply to Discussion, ... 290-291

Mule Haulage Underground at the Durban Roodepoort Deep Mine, by A. P. Roubillard, 31-33; Discussion, ... 139

Ore, Separation of Fine, before Milling, by E. H. Johnson, ... 180-181
Oxygen in Working Cyanide Solutions, The Estimation of, by H. A. White, 292-296; Discussion... 296-297

Packing Underground at the Ferreira Deep Mine, Systematic, by G. Hildick Smith and Paul Selby, 9-22; Discussion, 22-27; 39-46; 71; 103-111, ... 147-149

Phosphates, Conversion of Insoluble, by A. McA. Johnston, ... 140-141

Presidential Address, The, by G. Hildick Smith, ... 56-60

Pumps, Diaphragm, The Application of, to Metallurgical Work, by L. B. Eames, ... 95-99

Sand Filling of Mines, Further Notes on, by C. H. Greathead, 236-240; Discussion, ... 240

Shaft Pillar, Notes on the Removal of a Vertical, by J. Chilton, 297-300; Discussion, ... 300-301

Shoes and Dies, Electric Furnace Manufacture of, on the Witwatersrand, by Prof. G. H. Stanley, 72-82; Discussion, 85-87; 139-140; 186-187; 240-242; Reply to Discussion ... 268-270

Sodium Manganate, The Manufacture of Crude, for use on the Mines, by F. Wartenweiler, 161-162; Discussion, 183-184; 242-243; ... 303-304

Steel Melting Plant, Electric, by Prof. W. Buchanan, 83-85; Discussion, 85-87; 139-140; 186-187... 240-242

Underground Spring of Water, containing Manganese and Lithium, Notes on an, by John Watson, 181-183; Discussion, ... 183

Underground Workings, Notes on the Support of the, in the Mines of the Rand, by Percy Cazalet, 2-9; Discussion, 22-27; 39-46; 71; 103-111; ... 147-149

LIST OF OFFICERS FOR THE YEAR ENDING JUNE, 1918.

Hon. President:

H.E. The Right Hon. Viscount Buxton, P.C., G.C.M.G

Hon. Vice-Presidents:

His Hon. Sir F. D. P. Chaplin, K.C.M.G.
Hon. F. S. Malan, M.L.A., Minister of Mines.
E. A. Wallers, C.B.E. (President, Transvaal Chamber of Mines).
Sir Lionel Phillips, Bart.

Past Presidents:

Wm. Bettel, the Late
Andrew F. Crosse,
W. R. Feldtmann,
Charles Butters,
Julius Löevy,
John R. Williams,
S. H. Pearce,
W. A. Caldecott
William Cullen,
Edward H. Johnson,
John Yates,
R. G. Bevington, the Late
A. McA. Johnston,
James Moir,
C. B. Saner,
Walford R. Dowling,
Alex. Richardson,
G. H. Stanley,
Jas. E. Thomas,
J. A. Wilkinson.

President:

G. Hildick Smith.

Vice-Presidents:

H. S. Meyer,
A. Whitby,
H. A. White.

Ordinary Members of Council:

H. R. Adam,
J. Chilton,
K. L. Graham,
James Gray,
H. C. Hilton,
C. E. Hutton,
F. G. Macdonald,
C. Toombs,
F. Wartenweiler,
F. W. Watson,
John Watson,
E. M. Weston,

With the Past-Presidents, who are Members of the Council *ex-officio*.

Corresponding Members of Council:

E. G. Banks,
W. Cullen,
Clement Dixon,
Walter Neal,
C. H. Pead,
A. Richardson,
W. J. Sharwood,
T. B. Stevens,
Lieut.-Col. Ralph Stokes, D.S.O., M.C.
G. M. Taylor,
Major Gerald W. Williams, M.C.

Hon. Treasurer:

James Littlejohn.

Hon. Auditors:

Messrs. Alex. Aiken, and Carter.

Hon. Legal Advisers:

Messrs. van Hulsteyn, Feltham & Ford.

Editorial Committee:

G. Hildick Smith (*Chairman*),
H. R. Adam,
C. E. Hutton,
H. Meyer,
J. Moir,
A. Whitby,
H. A. White.

Finance Committee:

J. Littlejohn,
James Gray,
G. Hildick Smith,
John Watson.

Secretary:

Fred Rowland, M.B.E., Fellow, Chartered Inst. of Secretaries,
(P.O. Box 1183; Telephone 1101; Tel. Add: "Scientific"),
Old Municipal Buildings, De Villiers Street, Johannesburg.

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII. JULY 1917. No. 1.

Proceedings at a Joint Meeting of the Chemical, Metallurgical and Mining Society of South Africa, and the South African Institution of Engineers, June 30th, 1917.

A Joint Meeting of members of the two Societies was held in the Council Chamber of the Chamber of Mines, Market Street, Johannesburg, on Saturday, 30th June, 1917, at 8 p.m. There was an attendance of about 90, the members present of the Chemical, Metallurgical and Mining Society of S.A. being:—

26 Members:—Messrs. G. Hildick-Smith, H. A. White, J. Chilton, H. C. Hilton, H. S. Meyer, F. Wartenweiler, Profs. G. H. Stanley and J. A. Wilkinson (Members of Council), P. von M. Anderson, S. Beaton, P. Carter, P. Cazalet, A. A. Coaton, C. J. Gray, F. D. Hartley, R. N. Kotzé, C. D. Leslie, E. C. J. Meyer, P. M. Newhall, S. Newton, A. P. Rouillard, J. J. R. Smythe, T. P. Waites, A. J. Walton, J. J. Wessels and D. Wilkinson.

6 Associates and Students:—Messrs. G. J. V. Clarence, B. C. Forrest, E. G. Harding, L. D. Hingle, L. W. Macer and S. E. Willows Munro.

On the motion of Mr. G. Hildick-Smith, seconded by Mr. H. A. White, Mr. Bernard Price (Past-President, S.A. Institution of Engineers) took the chair.

The Chairman: I feel I am rather out of place in the chair at this meeting, because I am absolutely ignorant of all mining matters. There are two mining papers to be read to-night and, if it were not for the fact that the President of the Chemical, Metallurgical and Mining Society is joint author of one of the papers, I assure you I would have urged that he should take my place.

I feel on this occasion, and with papers of this class, it is the President of the Chemical, Metallurgical and Mining Society who should be in the chair to-night, but as you have done me the honour of asking me to preside, I can only say that it gives me great pleasure to have the privilege of presiding at a Joint Meeting of these two Societies. You know that I am one of those who favour a federation of the various societies here, and I hope very much that the representatives of our two Societies, who are being called together to consider this question, will be able to bring forward some really workable scheme which will meet with favour from members, and that this will be but the first of a large number of meetings at which we find ourselves in the same room. I think both Societies are to be congratulated upon the very good attendance to-night. I cannot lay claim to being a member of the Chemical, Metallurgical and Mining Society, though I should not require much persuasion to join up, but I believe that this gathering exceeds in number the aggregate of average attendance at the ordinary meetings of the two Societies, which fact augurs well for the endeavours we are making towards closer working.

I believe we have a number of visitors amongst us, to whom, on your behalf, I would like to extend a hearty welcome.

I have now very much pleasure in calling upon Mr. Percy Cazalet to read his paper.

NOTES ON THE SUPPORT OF THE UNDERGROUND WORKINGS IN THE MINES OF THE RAND.

By Percy Cazalet (Member).

Before beginning to read my paper, I must apologise for the apparently elementary nature of some of the opening portions of it. Much of it is, of course, ancient history to those who know the underground conditions on the Rand, but if the paper is to be of any use or intelligible to those who do not know the conditions at the moment, or who are living elsewhere, those points have to be mentioned, and therefore I hope you will excuse them.

Although not by any means neglected, it may be said, without fear of contradiction, that until within comparatively recent years the support of the hanging-wall, over the areas where the ore has been mined in the underground workings of the Rand, has not as a rule received much special consideration, and it is only during recent years that this matter has begun to force itself on the attention of those responsible for the safety of these mines. That this is so is quite natural, since the quartzites in which the Main Reef series of conglomerates are found, consist, for the most part, of a hard, tenacious, self-supporting formation, which only as a rule becomes treacherous when subjected to undue pressure through the removal over a large area of the underlying ore bodies, and which also produces a state of stress in any isolated blocks of ore left unstoped. Excessive pressure thus produced is found to cause the hanging-wall left thus unsupported over stoped-out areas to either become very treacherous or actually to cave; this state of affairs is often common at the junction of the boundaries of contiguous properties, even when not experienced earlier.

To those amongst the mining engineers of the Rand, who have been obliged to give much thought to this matter, it is becoming increasingly apparent that methods of work which have, generally speaking, been suitable in the past for the support of the hanging-wall, are so no longer on many mines, due principally to the two following factors:

1. That the workings of adjoining mines are practically assuming the character of continuous excavations unsupported, or only partially supported, over long distances.
2. The increasing depth of the workings.

So much has already been written about the Rand formations and workings, that it only here appears necessary to call attention to the fact that in spite of the extraordinary regularity of the Rand conglomerate beds over their known fifty miles in length and to a proved vertical depth of over 5,000 ft., there is yet a most marked variation in the stoping widths and angles of dip of the workings, and in the number and extent of the geological dislocations encountered in various areas; for example, there are mines on the Rand in which the total stoping width of the workings yielding profitable ore amounts to as little as 24 in. to 30 in., while there are other mines within a few miles of them in which the workings on the several reefs total as many feet in their aggregate stoping widths; again, there are mines practically entirely free from dislocation and igneous intrusion, and there are others intersected by innumerable faults and dykes, with greatly varying amounts of throw. The question of the angle of dip also is one in which just as much variation is shown, the workings varying from the truly perpendicular to the horizontal, and appreciable synclinal and anticlinal folds being also of fairly common occurrence. It is only necessary to compare the prevailing angles of dip of the Far East and the Far West Rand to accentuate this point, at the former the angle of dip being, say, from 8° to 15° as a general rule, while at the latter it is regularly 50° or over; while in the Central Rand whereas the outcrop was often vertical or nearly so, the general dip in depth is now about 40°.

It is evident from the foregoing, therefore, that the problem of the support of the hanging-wall on the Rand is by no means uniform in all districts or at all depths, and that generally conceived ideas as to the exceptional regularity of mining conditions on the Rand are only relatively correct compared with other mining districts, and are applicable rather to the persistence of the gold-bearing formation than to the mining conditions met with underground. This fact cannot be too strongly emphasised in all writing on the technical aspects of Rand mining, since many who by their familiarity with Rand mining problems should know this fact, yet by superficial comparison of results in working, appear entirely to overlook its bearing.

The methods of exploitation employed in most of the mines of the Rand have been the driving of levels 100 to 140 feet vertically apart on the plane of the ore bodies, which are thereby exposed for valuation purposes. The levels are connected in the direction of dip by winzes and raises, from which the exploitation proper takes place.

The methods of breaking ore which are employed vary considerably, as individual stopes may have any angle of dip and any stoping width between the extremes of 2 ft. and 33 ft. In certain mines there is only one profitable ore body, in others two, and in yet others three, while in exceptional cases even more occur overlying each other at greater or lesser distances apart, in which cases they are removed either in independent stopes or by the mining of the hanging or footwall of existing stopes. It is evident that no hard and fast rule can be given as to the methods employed or which should be employed for the support of the hanging-walls of these workings, but, generally speaking, it may be said that the method almost invariably employed until within recent years was to cut pillars of ore along drives and in the stoped-out areas, which were left *in situ* for the support of the overlying strata and the abandonment later of any given worked-out area, either with or without the previous deliberate recovery of the ore contained in these pillars.

While the excavated area in any given mine remains small and the workings on adjoining mines had not approached each other very closely, no serious objection to this system, beyond that of cost, existed; for, prior to there being any movement towards settlement of the general formation, this system certainly made for safety if used in conjunction with timber as auxiliary support for isolated portions of the hanging-wall requiring special attention. It is very doubtful, however, whether the use of pillars for the support of the hanging-wall in stopes has ever been justified on the score of expense, and in no single instance where detailed enquiry has been made by the writer has it been possible to show that the use of pillars has been justified on the grounds of economy in workings which were not badly cut up by faulting, or unless the pillars were only used temporarily to admit of the 'catching up' of sections of false hanging, when attempts were being made to reduce the breaking width of a stope to narrower proportions.

The *actual* cost of cutting a pillar is a difficult matter to arrive at, the more so, as during varying periods of the cutting process, the efficiency of the normal work of stoping is progressively interfered with up to the time when the pillar is actually cut through; while the method which is usually employed of paying for this work, by its inclusion in the all-round cost of breaking the ground, tends to obscure the matter further.

The system of leaving pillars of ore *in situ*, although it might possibly be defended under the circumstances of the past, cannot, in the opinion of the writer, be so defended under many present day conditions, and more so under the conditions likely to obtain generally in the future. As the purpose of pillars is to prevent the superincumbent formation from moving and settling, therefore as soon as they fail in this purpose by admitting any settlement, their whole utility is at an end, and the money spent in cutting them is wasted. The ore contained in them can, it is true, be recovered in many cases by the expenditure of both money and labour, especially when it is necessary, as in many cases, to re-open abandoned areas to do this; this is very largely being done at the present time in many of the older mines on the Rand. When the cost of cutting the pillars in the first instance is added to the cost of recovering them from old workings, it is evident to those conversant with the facts, that were there a satisfactory substitute for pillars in the first instance, the saving would be considerable and the loss of profitable ore much less.

Now, in ground supported by pillars one of two things happens: either the pillars *are* adequate to prevent movement in the superincumbent strata, which in a heavy mine would mean that a prohibitive amount of the ore reserves would be unavailable in the first working and also the breaking effect of the 'weight' of the overlying formation on the current faces is lost; or if *inadequate* to prevent movement, either the hanging or footwalls or the pillars themselves or both become shattered and a state of instability and tension is set up which is highly dangerous to the workers, and which would call for additional expensive support by other means. This is exactly what is taking place on the Rand to-day in a very large proportion of cases, for the mines in which full use of the 'weight' is being made to assist the breaking may be counted on one's fingers, while practically every mine, on the other hand, with any life behind it, is recovering an appreciable proportion of its ore from old stope pillars under circumstances which entail equally with other methods, at least the temporary support of the workings from whence this ore is being drawn, and which work is attended by a considerable amount of danger to the workers. Fortunately, it is found on the Rand, as elsewhere in mining, that the very fact of the work being recognised as dangerous results in extra precautions being taken, and the casualties in this class of work are nothing like so high as might be expected under the circumstances, and probably average less than in other and apparently less dangerous classes of work.

It may not be out of place here to outline shortly some of the after effects which have already been experienced on the Rand when pillars have been relied upon to support an undue proportion of the overlying strata.

(1) At the Ferreira Deep, where the total stoping width is about 11 ft. for the South Reef and Leader combined, the ore was mined in the usual way with, if anything, the leaving of a larger proportion of pillars, in the stopes, than is usually common: amounting to from 5% to 10% of the floor space. This mine is situated in the first row of deep levels, and owing to the prior working of the surrounding mines its blocked-out ground became completely isolated; from the point of view of 'weight' the underground conditions were also adversely affected by the nature of the local geological dislocations. The first effect of the extra weight thus released was shown by the failure of the stope pillars, which splintered badly; this was followed by the breaking-up of the hanging and footwall of the stopes, especially in the Main Reef Leader (the lower of the two reefs), where the formation is of a 'shorter' nature and has less elasticity. The threatened collapse of the stopes and the failure of the stope pillars was followed by the shaft pillars being called upon to carry an undue proportion of the weight of the overlying formations; these pillars also failed, and the timbering of both the five compartment rectangular compound shafts was badly damaged, the footwalls of the inclines were forced upwards and skip derailments became of almost daily occurrence.

(2) An area of a few claims had been isolated by the workings of adjoining mines; when these claims were jointly purchased and developed by the neighbouring mines it was found that within a few days of the advance of development ends, evidences of 'weight' such as had only been previously experienced in workings almost completely stoped out were noticeable; the sides of the drives scaled badly, and so-called 'air blasts' or pressure bursts were continually taking place; all pointing to the fact that the ore in this area would be very dangerous to mine. This has since proved to be the case.

Further instances of the above conditions could, if necessary, be quoted by all having Rand experience.

On the Rand, owing to the law of mining title giving ownership to only that portion of the mineral body which lies within the verticals of the surface boundaries, it is common practice for a mine during most of its life to attack what is virtually virgin ground as far as any considerations of 'weight' are concerned, but on the workings approaching its deeper or southern boundary it enters the region where 'weight' begins to tell, owing to its neighbour to the dip having already taken up the working of the ore bodies from the point at which it will itself have to leave off. That is, the major portion of its mining has been done under comparatively easy mining conditions, and it is suddenly confronted with virgin ground in its lower levels which has already been subjected to undue pressure, is fissured, and cracked, and is as a consequence an entirely different proposition from that met with in its own upper levels. Unless methods of mining and support in such cases are altered in time, serious difficulties must be experienced when stoping such areas.

At one time it was usual to believe that the quartzites of the Rand would, as it was called, 'arch themselves naturally' by successive cavings, and that the disturbances due to subsidence would not reach the surface unless very shallow depths only were involved. This view is now entirely exploded, for cracks of magnitude, the movements of which have been carefully measured, have appeared on surface, and their origin underground has been traced definitely; in one case this origin lies at approximately 1,500 ft. vertically below the surface, and in another at 1,200 ft. This subject is dealt with pretty fully in the reports of the Government Mining Engineer for the Union of South Africa for 1911 and following years, being also fully illustrated by diagrams.

When it became obvious that in order to

meet the changing conditions due to the increase of ‘ weight ’ in the workings of some of the mines, new methods would have to be applied, sand-filling was introduced with the greatest benefit, but it has up to the present been applied on a really large scale to but a few mines, although experimented with on a smaller scale by a further number. (Details of the methods used in sand-filling need not be given here, since the practice has become pretty general and data has been given in various papers.)

That sand-filling alone is going to be the current support required by our heaviest mines is unlikely, for two reasons :—

(1) Sand-filling is most difficult to apply to current stopes contemporaneously with the advance of the faces and sufficiently close to them to prevent the caving-in and sagging of the hanging-wall in the space between the sand-filling and the face.

(2) The great depth of the workings of the future causing increased difficulties in the lowering of the sand and in dealing with the water which must necessarily be used for its transport. ‘ Dry ’ lowering of sand into the mine is now being successfully applied however, and therefore part of the above water difficulty is obviated.

Sand-filling can be and is, however, satisfactorily used as support to the hanging-wall, where the ore has been mined over large areas, the hanging wall is thus allowed to settle *en masse* and the filling controls and minimises the extent of settlement. This applies, however, to its full extent only to those mines not subjected at the time of sand-filling to excessive weight, as the sand-filling can then be done before the collapse of the hanging-wall. In mines already subjected to great pressure there would be no large areas standing open, unless this type of filling was used as an adjunct to some system of thorough packing. Thus sand-filling can best be used as a preventive rather than as a cure. As one example of the preventive use of sand-filling at the early stages in the life of a mine the shaft pillars could, with useful effect, be surrounded by sand in anticipation of the time when increased ‘weight’ might reasonably be expected.

There remain, therefore, the following methods of supporting hanging-wall in such close proximity to the working faces as is required in our heaviest mines, to prevent accidents to the workers and the hanging-wall from caving.

(1) *The packing or stowage of waste rock* which is either broken during development or stoping operations or specially broken for the purpose. This system has its special uses, and should undoubtedly be more generally used on the Rand than it is at present. The failure to so use waste rock more generally is due chiefly to the underground lay-out most usual on these mines, and also to difficulties created by the angle of dip, when such dips lie, say, between 15° and 40°.

(2) *The square set method of timbering* so well known in many mining districts of the world is entirely unused in the stopes on the Rand, due chiefly to the absence of local suitable timber and the high cost of imported timber and of skilled labour.

(3) *The use of round timber for props, stulls and pigstyes* are other methods which are now largely used, especially in the last form. There are many mines now using pigstyes of both round and square timber with great success—in preference to leaving pillars—thereby solving some of the difficulties of the support of the hanging-wall at reasonable cost, for the moment. Quite recently a new form of built-up pigstye, consisting of blocks of end-grain timber spiked to binding planks, has been developed and largely experimented with on the Central Rand : data as regards this form of pigstye will, I believe, be made available by Mr. Hilton, of the Village Main Reef, shortly in the form of a paper, and it is only necessary here to say that indications to date are such as to believe that this form of pigstye will supercede other and more generally known forms very largely. It must be recognised, however, that no form of pigstye, which is not filled either with waste or reef, is of the least use for the support of heavy ground except for the most temporary purposes. With the undoubted increase to be expected in the cost of suitable timber in the future, however, together with the increasingly large proportion of the stoped-out areas which will have to be covered by any form of pigstyes in order to keep the workings safe, the cost of this method must become prohibitive, especially when the stoping widths are great. In the Ferreira Deep to-day as high a proportion as 61½% of the area stoped in a given month has had to be covered with packs to ensure safety.

(4) *The packing of ore actually broken at stope faces.*—In the writer's experience this is the only method which entirely meets the requirements—in workings where the angle of dip does not exceed 60°—of such

conditions of 'weight' as exist underground in some of our mines to-day and which will more commonly exist in more of our mines in the future.*

Systematic packing as a means of supporting one of the most treacherous hanging-walls of any mine on the Rand is a method not previously untried here, since it was applied at the Robinson and Ferreira Gold Mines some years prior to its application at the Ferreira Deep, with complete success.

The indirect advantages gained by this system of supporting the hanging-wall of a mine more than outweigh the cost incurred. Some of these advantages are:—

(1) Increased efficiency due to not cutting pillars.

(2) Increased efficiency due to the controlled 'weight' assisting in the breaking of the ore.

(3) Increased efficiency in working due to the prevention of the falls of hanging-wall which would impede stoping operations.

(4) Increased efficiency in shovelling by the concentration of broken ore in limited areas, as the packs prevents the scattering of the ore when blasting takes place.

(5) Increased efficiency due to the saving of time in bar-rigging and dismantling or repairing tracks, shoots, pipelines, etc.

(6) Immunity from accident.

It is only perhaps necessary to especially refer to the second and last of the foregoing advantages.

For the proper use of the effect of 'weight' in breaking it is necessary to have the continuous downward movement of the hanging-wall under proper control. This action of 'weight' can be seen most markedly on a stope face which has been left standing for a few days. In such a case it is necessary before stoping again takes place to dress down the face and remove the large flakes of ore which have become partially detached from the solid by pressure, and the whole face is found to sound 'drummy' when tested. As a further proof of this effect of 'weight' in improving the breaking conditions, it is interesting to note that since systematic packing has been general throughout the Ferreira Deep Mine an all-round reduction in the contract rates paid for stoping of from 10% to 20% has been possible.

The effect of systematic packing on accidents is no less marked. Before the alteration of system of support of the hanging-wall had been applied throughout the mine the loss of stope faces due to the caving in of the hanging-wall was a frequent occurrence, as many as nine stope faces being temporarily rendered unavailiable for working in a single month. On the other hand, since systematic packing has been general, during the past four years, no single stope face has been similarly lost, the packs having supported all threatened falls of hanging-wall with safety, and the casualty list of workers, which was previously most serious, has been reduced to normal.

A most noteworthy claim for this system of support lies in the attitude of the workmen affected by it. When it was first introduced it met with much criticism and opposition, and newcomers to the mine even now unthinkingly scoff at it and claim that money is being wasted in unnecessary precautions,, but in all cases they become strong advocates of the system even after only a short experience, and quickly make complaints to officials if they think packing is being neglected. Experience with this system has the curious effect of giving all its devotees a feeling of insecurity, however undeserved, in any mine where the system is not in use, wherever an area of hanging-wall of more than a few yards square is found unsupported.

Conclusions.—In the writer's opinion there is a grave moral to be learned by the Rand as a result of the experience gained at the Ferreira Deep, which unless taken to heart and acted upon in advance of the time when it becomes essential, will cause very serious loss of profits, unnecessary danger to those employed in mining our deeper levels, and which might even have the effect of rendering necessary the closing down of some of the less profitable of the deep level mines after large amounts of capital have been expended on their equipment and development.

The exigencies of finance make necessary two factors which have an important bearing on the methods of mining adopted from the beginning of a mine's life. The first is that the deeper mines are necessarily confined to a few only in the first instance, and not until these have proved their success are others opened up alongside of them; the second factor, and this has an equal

---

*Note.—For details of this system and to arrive at a knowledge of what are actually the underground conditions on some of the mines of the Rand, see the paper by G. Hildick-Smith and Paul Selby, entitled "Systematic Packing Underground at the Ferreira Deep Mine (published in this *Journal*) which should be studied in conjunction with the present one as they are complementary to each other. For this reason it has purposely been arranged that the two papers should be read and published together, thereby avoiding unnecessary repetition.

bearing on results, is that the capital available and the time factor in the opening up of a deep level mine on the Rand prevent the adoption of the ideal method of working home from the boundaries towards the shafts, and call in practice for the adoption of exactly the reverse method.

Consider the effects of these two points: A deep level mine begins work in virgin ground surrounded on all sides by normal conditions in the formation which is to overlie the workings of the future. No undue stress due to 'weight' is experienced, and the hanging-wall of the workings is therefore free from the shattering effects which it will experience in the future. The 'weight' to be supported in the beginning is not even that which is due directly to the depth of the workings, since the limit of elasticity of the formation is not reached until some time after ore has been mined over large areas, nor have the effects of neighbouring workings to be considered, since these are as yet non-existent. A false sense of security is engendered, and the early behaviour of the hanging-wall is taken as an index of its future behaviour. A standard of production both in output per labourer and in gross is set, which requires a great deal of moral courage on the part of the technical advisers and very pronounced evidences of the inadequacy of the system of support in use, before it can be departed from and the output deliberately reduced during such time as systematic packing of ore is being introduced. That is, unless the system is started from the first only great moral courage and foresight on the part of the mining engineers responsible can prevent the debacle which is as certain as is anything in our very inexact science of mining.

It must be remembered that there are already several mines on the Rand whose workings lie at vertical depths of between four and five thousand feet—two mines at least have reached a plane below this latter figure—and that the formations lying above and very generally also below the gold-bearing conglomerates consist of exceptionally hard and inelastic quartzites which splinter freely; further, that so-called 'pressure bursts' are already very prevalent in some of the deeper mines; these consist of the sudden release of tension in the rock, acompanied by loud reports when large pieces of the working face become detached and are shot considerable distances away from the face. The causes of this phenomenon have been the subject of much discussion, but there can be no doubt that it is increasing with depth, although more pronounced in some areas than in others. Pillars left *in situ* are specially prone to this behaviour, so much so that in mines where pressure bursts are common it is necessary to 'house' the pillars with timber, for the protection of the workmen.

The first mining operations in a deep level mine of the Rand, where later much trouble with the hanging-wall must certainly be anticipated, begin, therefore, under conditions which do not, on the face of things, call for ultra careful mining methods being adopted, and where precautions if taken from the first have the appearance of waste of money and of an exhibition of undue caution; neglect of these is therefore almost inevitable unless where personal experience or study of such conditions in actual practice has stamped the matter definitely on the memory and conscience of those responsible for laying out such a policy of working from the commencement. It has already been shown how difficult is the introduction of such methods later, until the damage has already been done and loss of profit and needless danger has made itself felt.

The second point to consider is the financial impossibility of postponing production until all the breaking of ore could be carried on from the boundaries working homewards. There is no doubt that if financial considerations did not make this impossible all engineers would prefer to adopt the practice of concentrating on the development of the properties to their boundaries first and then mining all ore from the boundaries towards the shaft, exhausting the areas of payable ore in one operation and abandoning once and for all the worked-out areas, after stowing therein all waste and any unpayable ore broken. There is no doubt also that only thus could the safest and cleanest mining possible be done and with the least difficulty in the support of the hanging-wall, but even granted this ideal method of working was possible, the writer is of the opinion that in areas on the Rand where 'weight' is really already telling it would still be essential to support the hanging-wall of these stopes by the systematic packing of ore.

Unfortunately the delay in opening up a mine on the principle of working from the boundaries homewards would be so great that the loss of interest on the money invested in equipment and development would make the scheme impracticable. A combination of the present and the ideal methods of development and exploitation, however, is in some cases possible, and especially so in the case of the greater number of the Far East Rand mines, where the dip of the formation and system of development, in large blocks, lend themselves to reaching the boundaries of the properties much earlier than can be done generally on the Rand, and it is here urged that those responsible for these properties should so lay out their development as to allow of mining by this method at the earliest possible moment, even though, through force of circumstances, they are obliged to commence exploitation on the other and more usual system.

With regard to shaft pillars, the writer is of opinion that within a comparatively few years it will be recognised that shaft pillars, left for the support of vertical shafts, are not only unnecessary but an actual danger on our deeper mines, and that underground lay-outs will be so designed as to do away with them entirely, except where large areas of very low grade ore exist in the position of the shaft pillars. This will require, however, a complete revolution of all preconceived ideas, and is a subject which is worthy of being dealt with in a paper by itself at some future time; meanwhile we have to recognise that methods of support adopted must take into consideration the facts that vital shaft pillars do exist, which are often quite inadequate in strength for their purpose or the strain which later will be imposed upon them.

The writer is conscious of the many omissions and the incompleteness of these notes on a subject which is almost endless in its variations and of such vital importance to miners, but these papers have purposely not been overloaded with detail because of the danger of the criticism and attention which it is hoped they will originate, being diverted to such details *instead of being directed to the vastly important main issue of the system of support to be applied to our workings, and the absolute necessity of such support being decided upon and applied before it is apparently required.* It is, in the writer's opinion, so essential that this should be done, and done in time, that it is safe to prophesy that no mine on the Central Rand will be other than a struggling concern subject to grave danger of constant collapse in ten years' time from now, unless worked entirely on the plans outlined in this paper or supported by some other method, as yet untried on the Rand, which *gives support concurrently over practically the whole of the areas stoped while access to such areas remains necessary.* Such a system, must, however, admit of the continuous settlement of the overlying strata being under control, and must abandon once and for all the present fallacy, disbelieved when carefully considered and yet so often acted on in practice, *that resistance to settlement of the whole country is possible at any but comparatively shallow depths.* Not alone can this prophesy be applied to the Central Rand, but it is also applicable to certain areas of the Germiston district and to parts of the Far East Rand; such areas will require the same treatment within the same period or they will behave similarly.

The bulk of the foregoing notes was written between three and four years ago while the writer was on a holiday trip to the Old Country, and while the position was such that on this subject advocates of the principle here outlined were like voices crying in the wilderness. Since that time it is interesting to note that many engineers, managers and members of underground staffs have inspected the reef packing system in actual practice and the conditions of the hanging-wall to which it has been necessary to apply it, and, as a consequence, to-day the system is receiving more support and agreement than would have been the case at that time had this paper then seen the light of day.

If any one man is to have the credit for introducing the ore packing system to the Rand it should be given to Mr. Paul Selby, who first introduced it on the Robinson Gold Mine in 1906 while holding the position of Acting Manager of that mine, and who subsequently extended its use to the Ferreira Gold Mine at the end of 1907. Since then the details have, of course, been largely developed under Mr. Trump at the Ferreira Deep and Mr. Palmer Carter at the Robinson Gold Mine, both of which mines are to-day still running and not merely memories and holes in the ground, solely due to the use of systematic ore packing.

This paper, together with a proposed complementary paper by Lt.-Col. Trump, D.S.O., and Mr. G. Hildick-Smith, would have been presented much earlier but for the fact that Mr. Trump left for active service in Flanders and France, and that

Mr. Hildick-Smith's absence in German West and later promotion to another mine have necessitated delay in presenting them.

Messrs. Smith and Selby deserve your thanks for the amount of work they have put into their paper and for the preparation of the photos, slides and diagrams, which have served jointly for both papers.

SYSTEMATIC PACKING UNDERGROUND AT THE FERREIRA DEEP MINE.

By G. Hildick-Smith, B.Sc. (President) Sc. and Paul Selby, B.Sc.

The Ferreira Deep Mine now consists of the following original mines:—The Ferreira G.M., including the original Worcester G.M. (to-day called the Outcrop Section) and the Ferreira Deep (Deep Section). These mines were amalgamated in 1912 to form the present Ferreira Deep The position of this mine relative to the surrounding mines of the Central Rand is shown in Fig. 1.

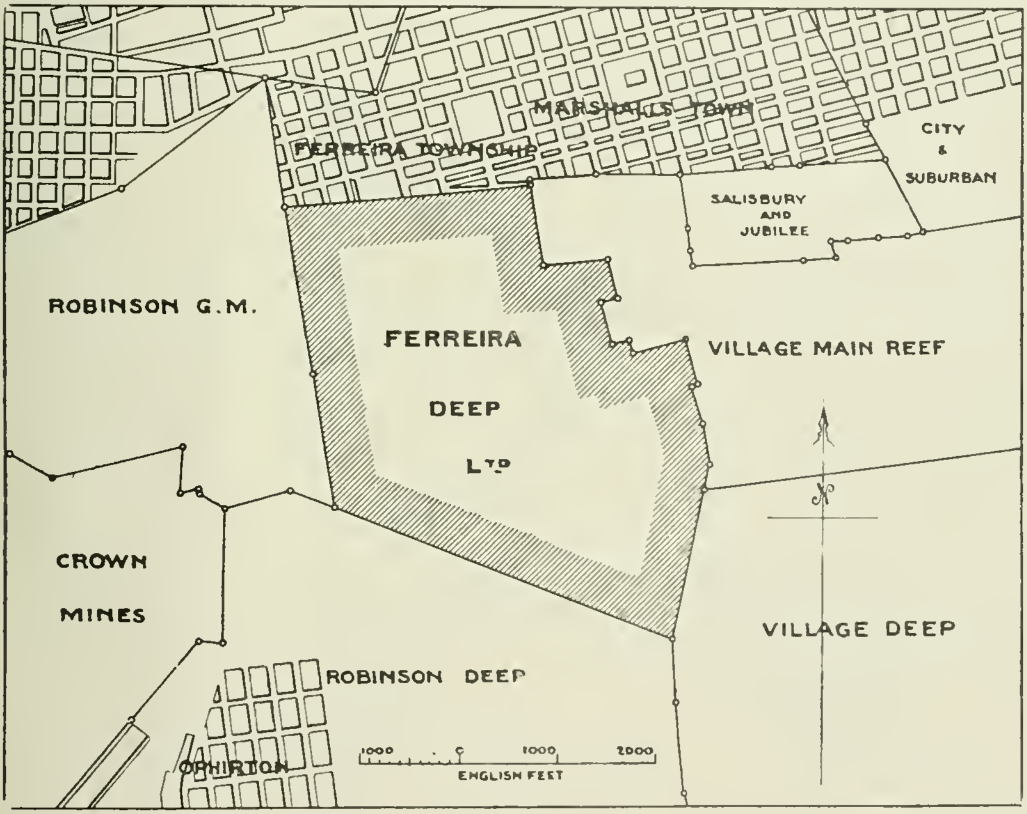


Fig. 1.

The reasons for the somewhat sudden alteration in the nature of the hanging-wall at the Ferreira Deep, and hence the necessity for introducing systematic packing can be easily understood, if the blocked-out ground and pillars left in the mine are looked upon as the fulcrum over which a large area of the overlying strata of this section of the Central Rand is bending.

Referring now to the Deep Section of the mine only, the blocked-out ground here had been completely isolated, due to the fact that in the adjoining mines practically no solid ground has been left standing for some years near the Ferreira Deep boundaries. The same conditions existed nine years ago in the original Ferreira Gold Mine. It is interesting to note that both of the original mines now forming the Ferreira Deep have passed through the same phases under-

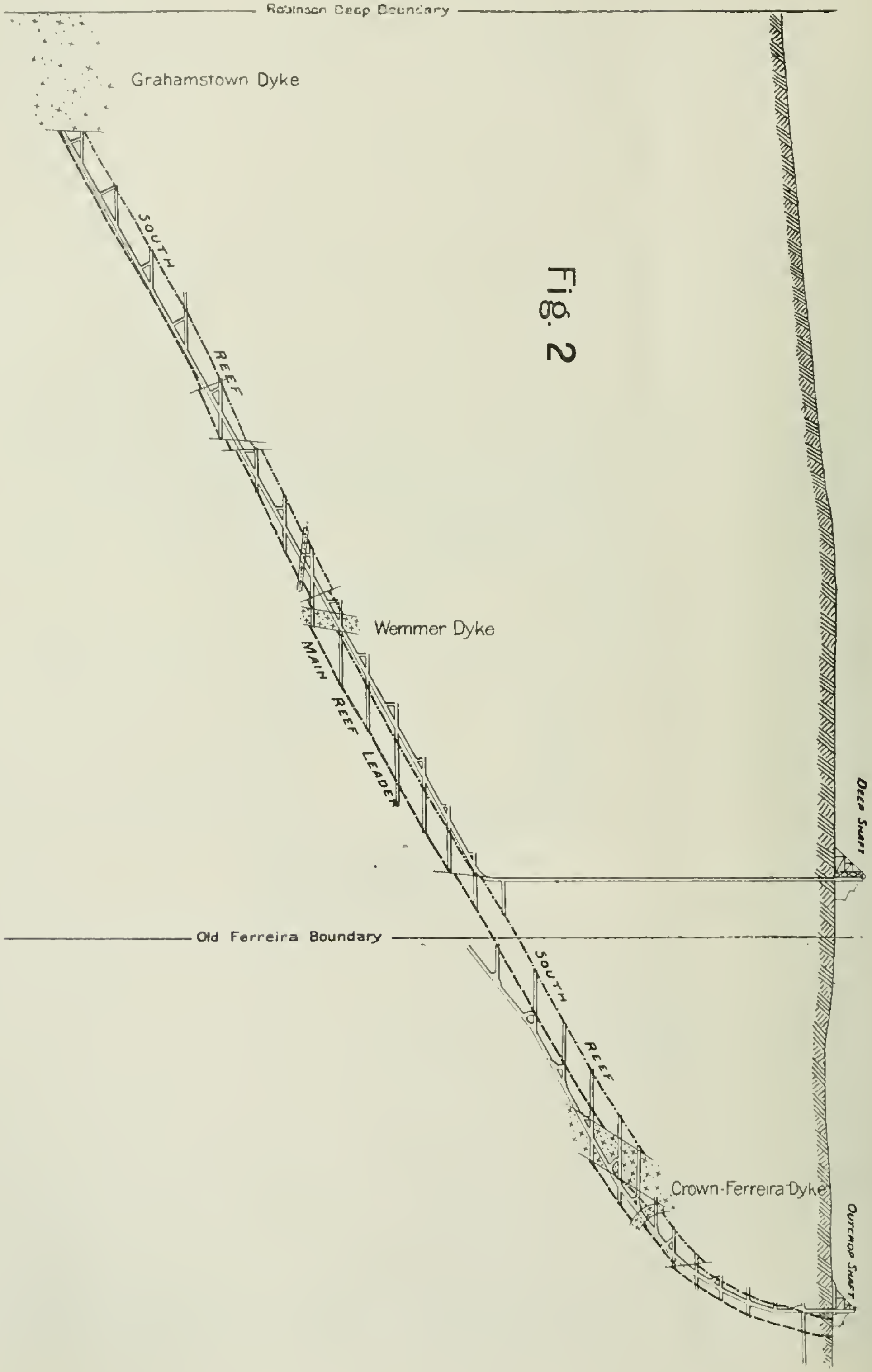

Robinson Deep Boundary
Grahamstown Dyke
Fig. 2
SOUTH REEF
Wemmer Dyke
MAIN REEF LEADER
DEEP SHAFT
Old Ferreira Boundary
SOUTH REEF
Crown-Ferreira Dyke
OUTCROP SHAFT

Fig. 2.

ground. At the commencement of the life of each mine the hanging-wall consisted of a naturally strong quartzite, and pillars were cut along the drives and in the stopes to support the hanging-wall which, at that stage, called for no more support than average Rand hanging-wall. As stoping continued over large areas, the weight of the superincumbent strata began to affect the condition of the hanging-wall, more timber was used, combined with the increased cutting of pillars. Eventually the weight to be supported by the blocked-out ground and pillars became so great that the blocks and pillars punched through the hanging-wall or burst out altogether. The nature of the hanging-wall was completely changed throughout the mine and became very broken and dangerous, causing stopes to cave and shafts to give trouble. Under these conditions systematic packing in conjunction with the removal of pillars, which were replaced by packs, was resorted to, thus saving the mine.

The reefs mined to-day are the Main Reef Leader and South Reef. On the western section of the mine the Main Reef Leader directly overlies the Main Reef, and in the upper levels of the mine the top bands of the Main Reef were usually included in the one stoping face, the average stoping width in these cases being about 92 inches. In the eastern section of the mine the Main Reef Leader only is stoped, the Main Reef being separated from it by a very thick parting, the average stope width of the Leader stopes in this area being 70 in. The average Leader stoping width over the whole mine is now 73 in. The South Reef overlies the Main Reef with 80 ft. of intervening quartzite, the average stoping width on the South Reef being 61 in. Generally speaking, the hanging-wall of the South Reef is stronger and more elastic than that of the Main Reef Leader; this is often due to the effect of South Reef pillars and blocked-out ground having a punching effect through to the Main Reef Leader. An interesting example of this is described in the appendix No. 1. The dip of the reefs, as will be seen from the section Fig. 2, varies in the Outcrop Section from 80° to 29°; in the Deep Section the average dip is 29°. Other things being equal, the system of packing adopted depends on the degree of the dip.

Systematic packing as employed on the Deep Section.—Prior to the amalgamation in 1912 trouble was first experienced on the Deep Section in the shafts. A rough idea of the position of the shafts with regard to the reefs can be obtained from the shaft section, Fig. 2. Unfortunately the shaft pillars left with the original system of supporting the hanging-wall by pillars were of such a size and position as to defeat the object for which they were cut. In order to relieve the pressure on the shaft pillars a sand-filling scheme was adopted, and actual filling commenced in June, 1910, 773,629 tons of sand being filled into the areas shown (black) in Fig. 3 (see next page). As the breaking up of the hanging-wall all over the Deep Section of the mine continued and stopes were constantly caving, with a consequent decrease in the tonnage mined, systematic packing on the stoped-out areas, as stope faces advanced, was adopted with excellent results such as had been obtained several years previously in the Outcrop Section.

The various methods of packing in stopes of the Deep Section which have been found to be most efficient are as follows:—

(A.) *Packing in typical Main Reef Leader machine stopes of an average stoping width of 75 in.*—In this class of stope the hanging-wall is usually so bad as to necessitate packs being built within from six to eight feet of the machine benches. The packs are built of broken ore from the current stope faces, and are supported in the first instance by timbers and lagging poles as shown in Fig. 4. The foundation timbers, Fig. 5, are about 10 in. in diameter and 10 ft. apart, carefully placed in hitches, but without headboards. It is essential that these timbers should be set in such a way as best to withstand the shock from blasting, which would be impossible were headboards employed. Lagging poles, 12 ft. long by 3 in. in diameter at the small end (old pipes or rails are also used) are placed across the timbers, beyond which they project about 1 ft. The lagging poles are

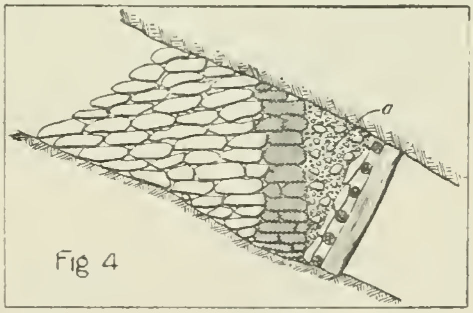


Fig 4

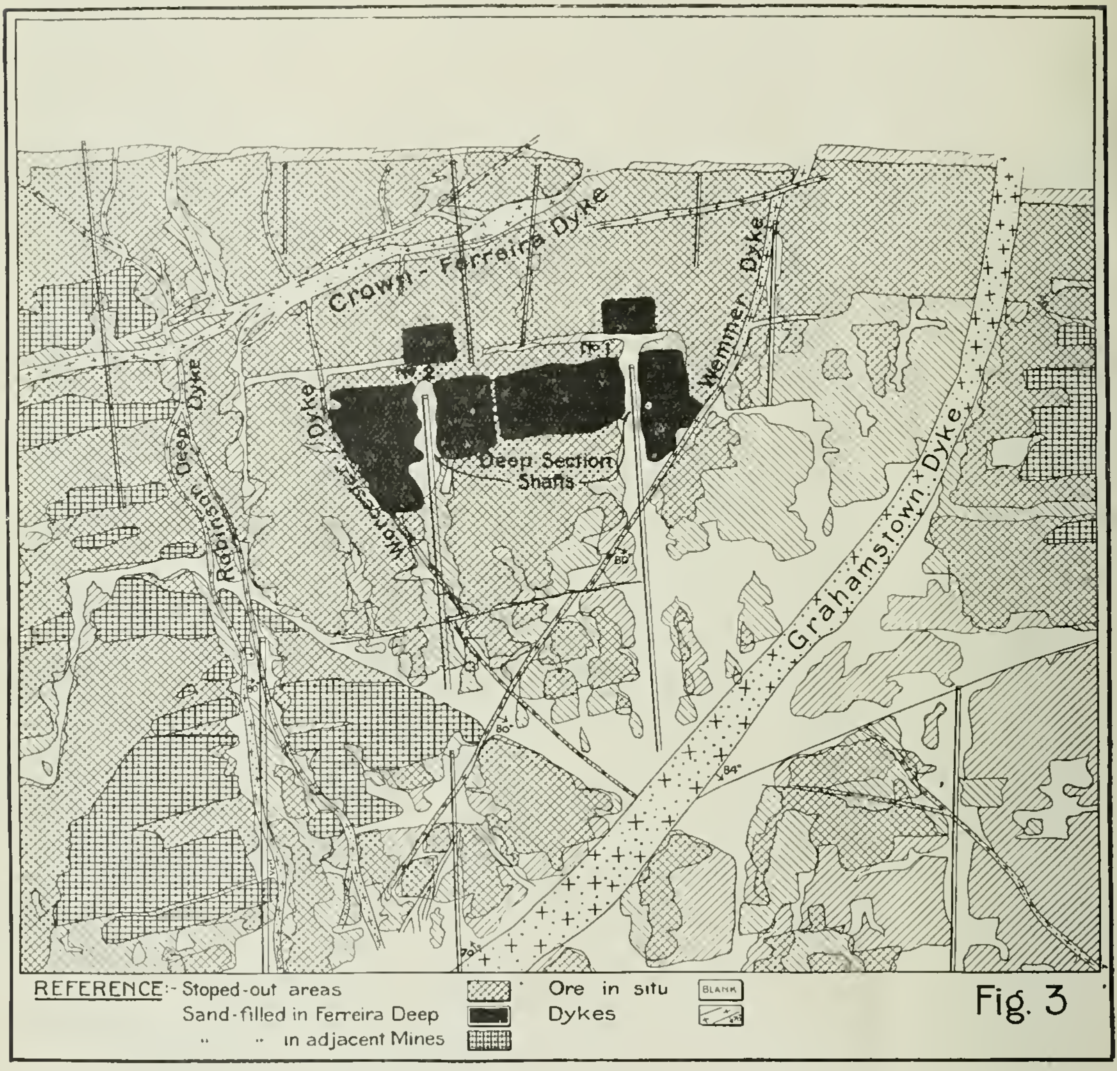


Fig. 3.

placed about 12 in. apart to allow for 'wings' being built on to the pack, a 'wing' being a lateral extension to the original pack formed by placing lagging poles over one of the stull posts of the original pack between the ends of its lagging poles and over a new timber placed as required, thus the pack foundation is widened and packing continued off the new extension. An important point in the actual stonewalling operations, when building packs of this type, is that care should be taken in building the back-wall of the pack shown (hatched) in Fig. 4. This wall must be so built that, when the timbers and lagging poles fail or are removed, only the filling falls away (see Fig. 4A). The advantages of this type of pack are:—

1. Timbers and lagging poles can be withdrawn and used over again.

2. If, due to pressure or blasting, timbers become broken or fail, only the filling falls away, the main pack still supports the hanging-wall.

It is essential, in building packs of this type, that the back and retaining walls are commenced with the main footwall as a foundation, and not built on loose, broken rock. The retaining wall farthest from the stope face should at all times be built up ahead of the one nearest the face. This saves time and cost in packing, as the rock from the blast is shot into the pack. In this way the actual packing operations consist of carefully building the walls of the pack, the centre being filled with loose rock, mostly through the medium of the blast. Packs of the above type are found most satisfactory in stopes where heavy blasting is done. This type of packing can be adopted most successfully in stopes dipping at angles from 10° to 35°. The maximum angle of dip suitable for this type of pack would depend on the nature of the footwall and is governed by the question of safety, for in the event of the timbers falling away where the dip is too steep, the rock might roll down the stope and be a source of danger. Generally speaking, in stopes dipping steeper than 35°, a pigstye foundation for the pack is safer. Solid ground is sometimes used as a pack foundation.

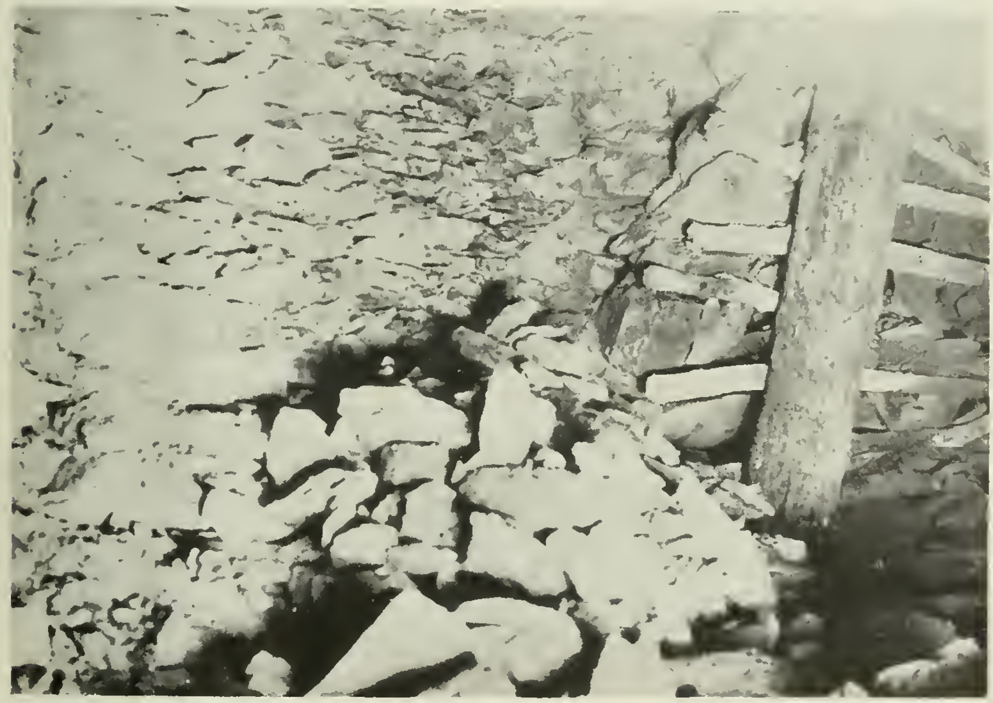


Fig. 4A.

(B.) *Packing in Main Reef Leader and South Reef stopes of an average stoping width of 66 in.*—The stoping in this class of stope is generally done by small machines or hand labour, the blasting is, therefore, not so heavy as in stopes where the type of packing used is that above described, and modifications of this type of packing are employed with a view to the saving of time and timber. Originally pigstyes, as shown in Fig. 6, were used either alone or as a foundation for packing. The pigstyes were built either of square or round timber 8 ft. long by 5 in. thick, square timber being the easiest to handle in steeply inclined stopes. The foundation on which a pigstye is built consists of two lagging poles set as stull pieces (Fig. 6) and by the time these poles are broken by the subsidence of the hanging-wall, the pigstye has been tightened sufficiently to stand by itself. When pigstyes are built near the stope faces they are either filled in with broken ore or waste rock, and on the side nearest the stope face broken ore is stacked to act as a buffer against blasting, and thus prevent the pigstye, before it has become tightened by weight, from being blasted out. Occasionally the pigstye is tightened in position by the use of wooden wedges. Recently packs have been substituted for pigstyes to save timber, the type of pack used in this case is a modified form of the pack already described in Section A, short lagging poles in some

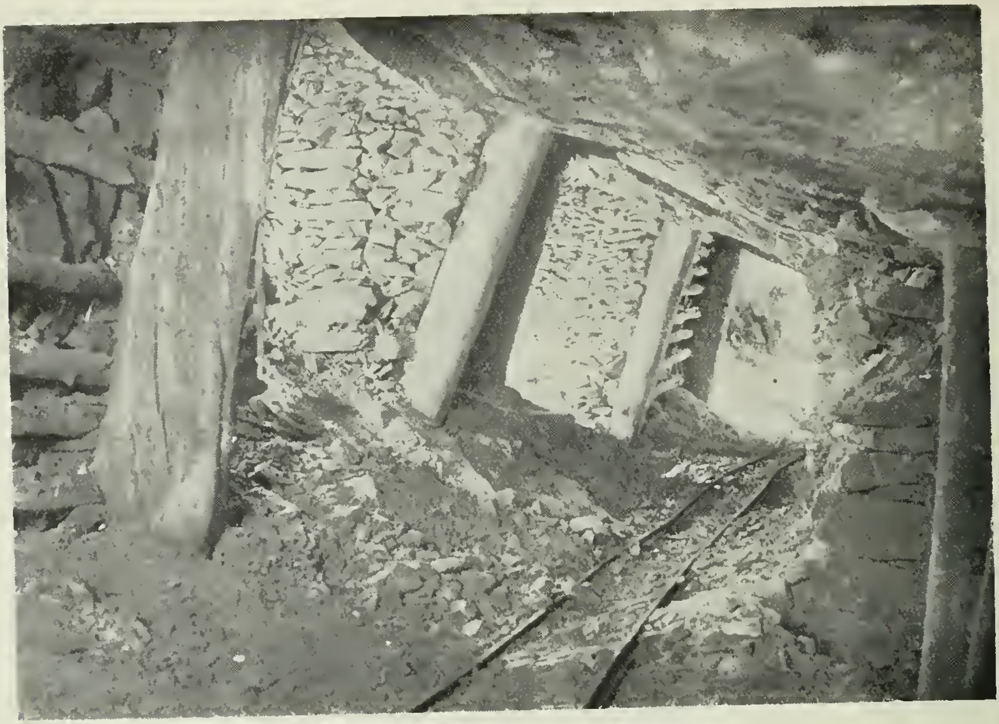


Fig. 5.

Fig. 6.

ıd
ıe
ɔe
se
ɜh
ıe
to
ld
ef
to
as
in

—

er-
ıe
ɜd
pe
re
m
al
ɜd
ɜr-
ks
gh
is
is
re-
at
ɜr-
ill
ɔe,
ft.
ed
ek
ed
he
ed

in
tic
wo
ıal
be
ıa-
nd
of
all
se,
ge
ıb-
is
m-
ew
nal
by

during the same period. Fig. 9 shows graphically, in square fathoms, the areas stoped and covered by reef packs, monthly

as much as half or more, as can be seen in (Fig. 9A.). This compressing effect on the packs has the result of making reclamation

FIG. 9.

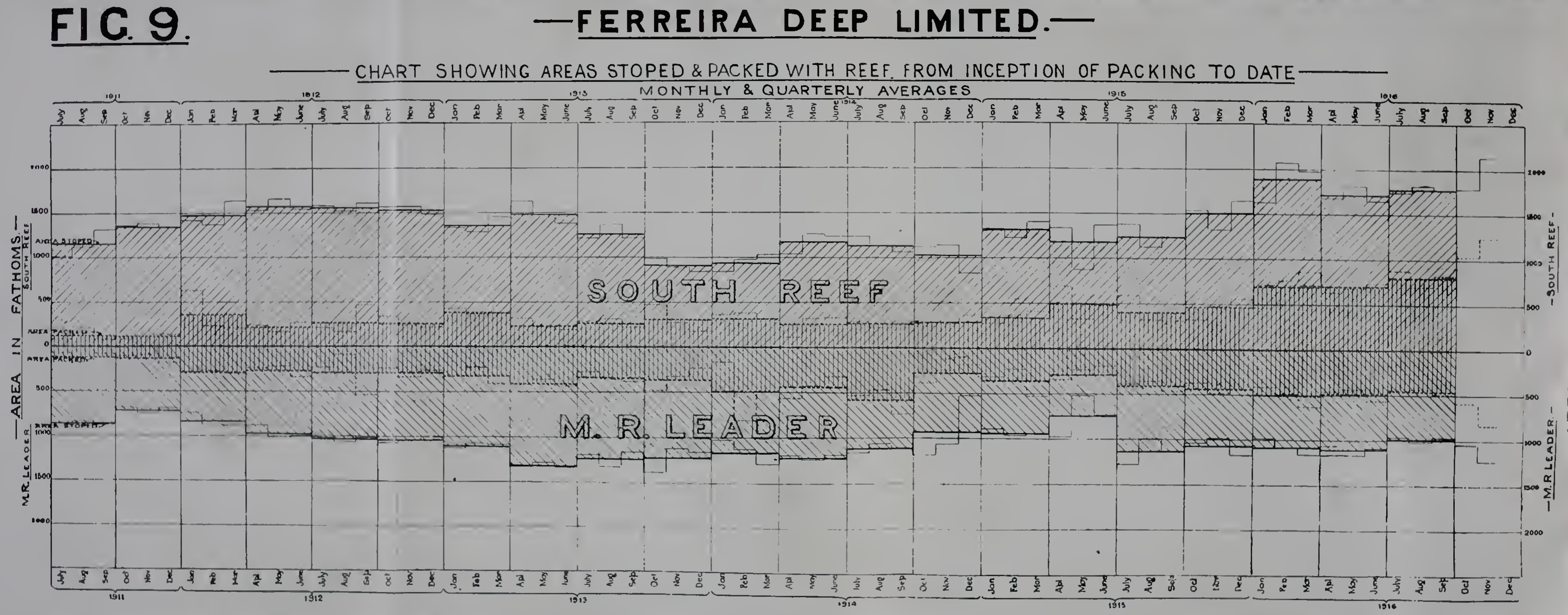

—FERREIRA DEEP LIMITED.—
CHART SHOWING AREAS STOPED & PACKED WITH REEF, FROM INCEPTION OF PACKING TO DATE
MONTHLY & QUARTERLY AVERAGES
1911
1912
1913
1914
1915
1916
July Aug Sep Oct Nov Dec
Jan Feb Mar Apl May June July Aug Sep Oct Nov Dec
SOUTH REEF
M. R. LEADER
AREA STOPED
AREA PACKED
AREA PACKED
AREA STOPED
AREA IN FATHOMS.
South Reef
M.R. Leader
2000
1500
1000
500
0
500
1000
1500
2000

Fig. 9.

cases being substituted for the timbers, and in other cases a back-wall is built up either off a suitable foundation on the footwall or off a lagging pole, old pipe or rail laid across two jumpers placed in holes drilled in the footwall, as shown in Fig. 7. Packing in close proximity to the working face, and therefore subject to blasting, requires to be done with more care than packing away from the vicinity of blasting.

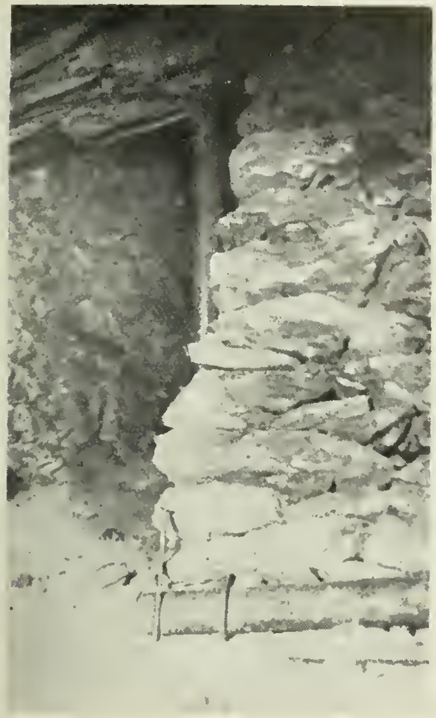


Fig. 7.

(C.) *Packing in places not subjected to blasting.*—In such places where the hanging-wall has to be supported, pigstyes, preferably built of old timber, or packs of waste rock only and of the type shown in Fig. 7 are generally used.

Area covered by packs.—Fig. 8 is a stope plan of a Main Reef Leader stope packed with packs of the type described in Section A, the packs being shown hatched. In such stopes from 42 % to 70 % of the area stoped out was covered by packs during 1916. In the South Reef stopes the area packed varied from 32% to 66% of the areas stoped during the same period. Fig. 9 shows graphically, in square fathoms, the areas stoped and covered by reef packs, monthly and quarterly averages for South Reef and Main Reef Leader from the inception of the packing to date. The main feature to be noted from this table is the gradual increase in the percentage of the area stoped, which has been covered by reef packs as the mine became heavier, from 15% in July, 1911, to 57% in December, 1916. Under the old system of leaving pillars in the Main Reef Leader and South Reef stopes, from 5% to 10% of the blocked-out ground was left as pillars above and below the drives and in the stopes.

Pipe lines and intermediate tracks.—Systematic packing facilitates stope watering and the supply of compressed air to the machine stopes, as pipe lines are placed through the stopes away from the stope face and behind the packs so that pipes are rarely put out of order by blasting. From the pipe lines down the stopes horizontal branch lines are connected where required and extended to the stope faces. Intermediate tracks are laid between the packs at distances of about 50 ft. apart through the stope (see Fig. 5). On these the ore is trammed to fixed footwall chutes. This is found to be the most efficient means of removing broken ore from a stope dipping at 29°, but the packing system makes intermediate tracks on this angle of dip still more efficient, as in a large machine stope, for example, where packs are only 10ft. from the face and a bench has been blasted between the pack and the face, the quick clearing away of the broken ore is facilitated by means of small trucks run close to the face, and bar-rigging can be commenced sooner.

Reclamation of ore originally packed in the first period of working.—Systematic packing of ore and waste rock entails two distinct periods of working, the original packing following the stope faces may be looked upon as the first, and the reclamation of the ore in the packs the second period. Generally speaking, the result of systematic packing is that the hanging-wall over the stoped-out area settles *en masse*, the packs preventing caving over large areas. Again, the result of the slow subsidence of large areas of hanging-wall is that the packs and pigstyes become compressed to such an extent that a few months after stoping is finished the original stoping width is reduced, in some cases, by as much as half or more, as can be seen in (Fig. 9A.). This compressing effect on the packs has the result of making reclamation work an easier and safer operation than it would otherwise be, due to the fact that at this stage the hanging-wall has lost its original liveliness and assumes more the

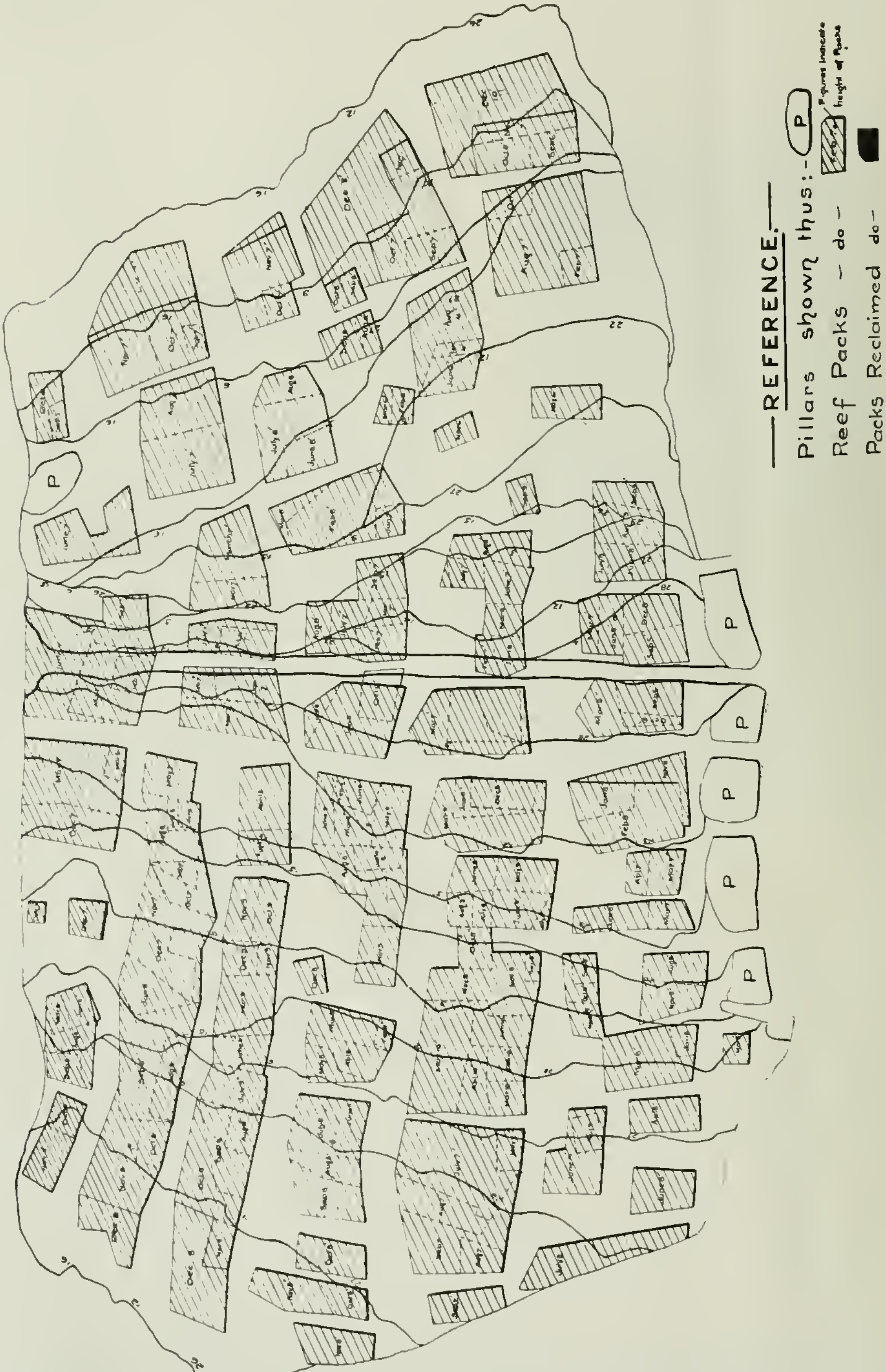


Fig. 8.—Ferreira Deep, Ltd. Stope $\frac{3W}{12}$ MRL.

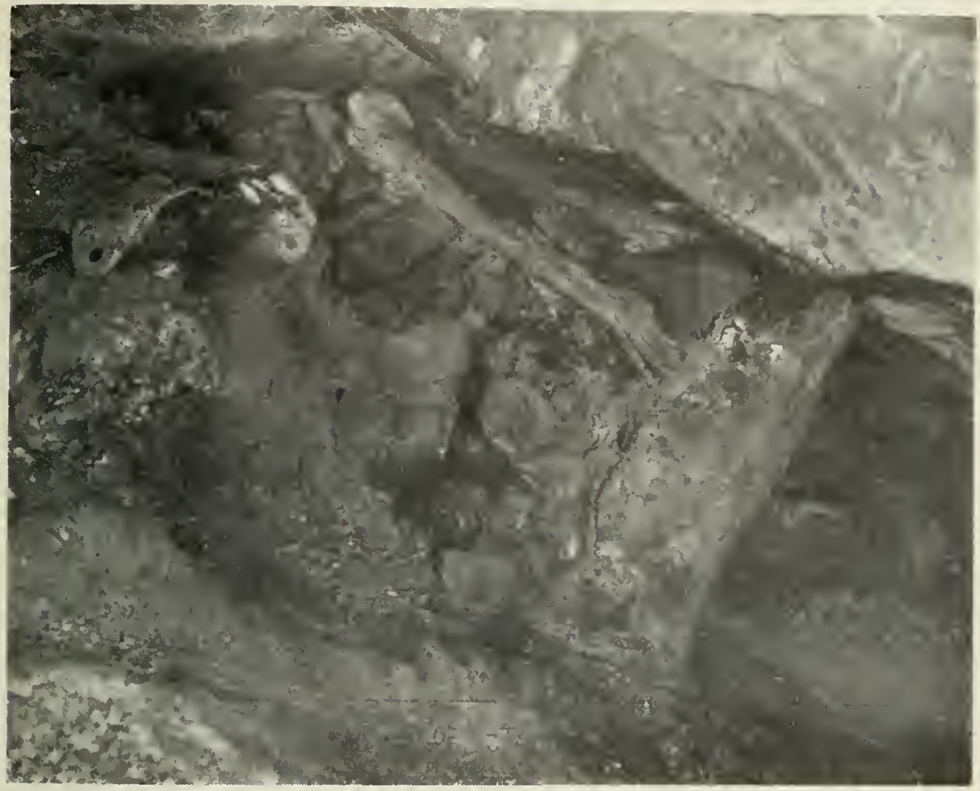


Fig. 9A.

nature of a dead weight, and also due to the fact that the packs are then so tightly squeezed (see Fig 10) that they remain in position without any foundation of timber or pigstyes, so much so, that small portions of packs of whatever size required, can be left temporarily when necessary, as support as reclamation proceeds, to hold up any bad portion of the hanging-wall. A few cases have occurred where it has been necessary to drill and blast out the packs. It is interesting to note that Figs. 9A and 10 were obtained from photographs, taken on the same day, of different portions of the same reef pack at distances of 50 ft. from each other.

Reclamation work amongst packs is greatly facilitated by the original intermediate tracks, these, together with water-pipe lines and chutes, being left in the stopes after the first period of working. The hanging-wall is supported during the removal of the original packs by the use of systematic temporary supports in the form of lagging-poles, combined with the repacking of the waste rock found and also by pigstyes, as shown in Figs. 10A and 11. In rare cases parts of the original pack have been left where the hanging-wall is very dangerous, but on the whole the quantity of ore unrecoverable from the original packs is negligible. In any case this is more than counterbalanced by the extra ore, which is often left inadvertently in the hanging or footwall during the original stoping operations being at this stage taken out. (Note the footwall band of South Reef shown in Fig. 10.) As reclamation proceeds a good supply of water is used to facilitate sorting and for the final washing of the footwall. In reclamation work no definite system of secondary packing is employed, as it is better to adopt the method considered most suitable in each case. The essential points are that as little new timber as possible is used, and only waste rock left behind. The general idea of the second working is to obtain all the ore possible with a maximum of safety at the time of working, as, after the reclamation work is finished, the extent to which the old stopes cave in, except in special cases, is of no consequence.

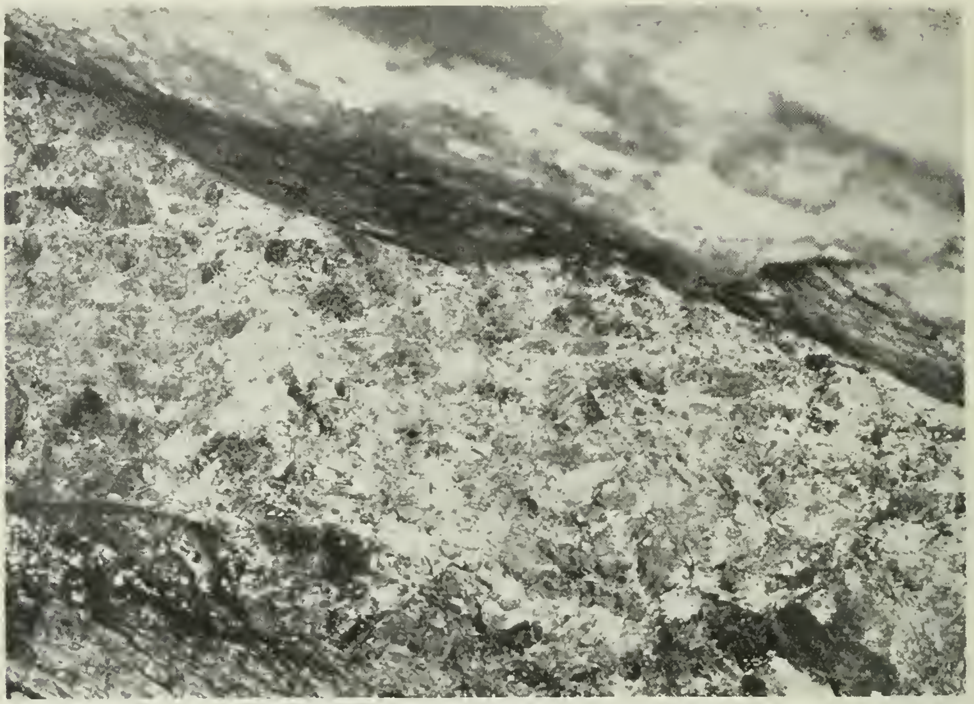


Fig. 10.

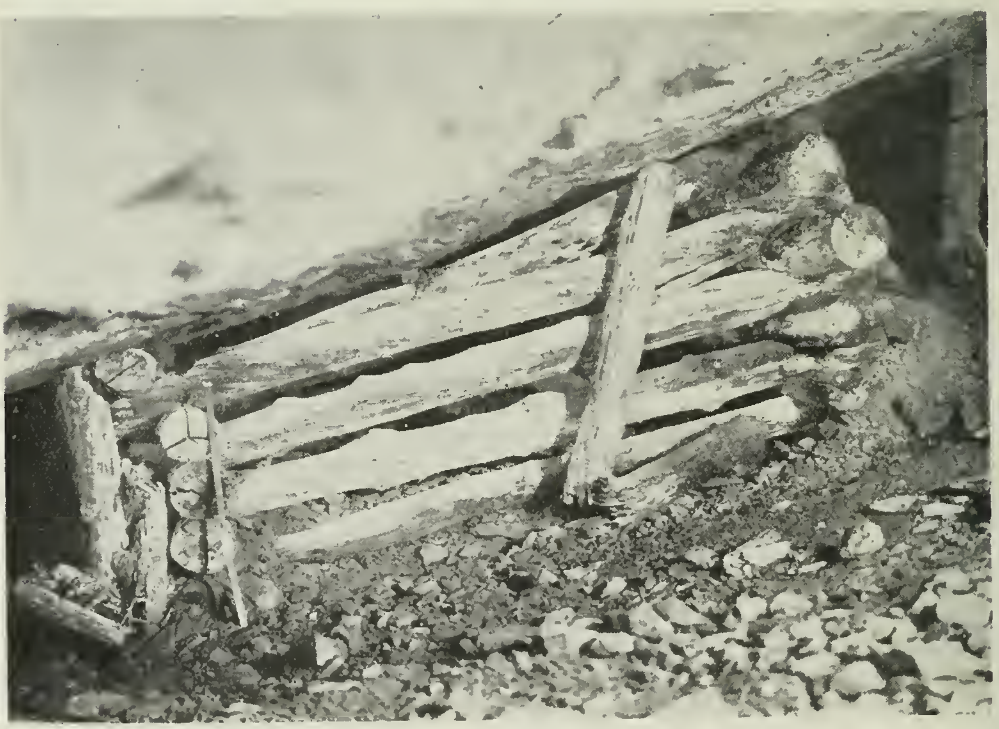


Fig. 10A.

FIG. 13.

FERREIRA DEEP LIMITED

— CHART SHOWING TONNAGES MINED, RECLAIMED FROM REEF PACKS, OTHER RECLAMATION, — & TONNAGES PACKED, IN QUARTERLY AVERAGES FROM INCEPTION OF REEF PACKING TO DATE —

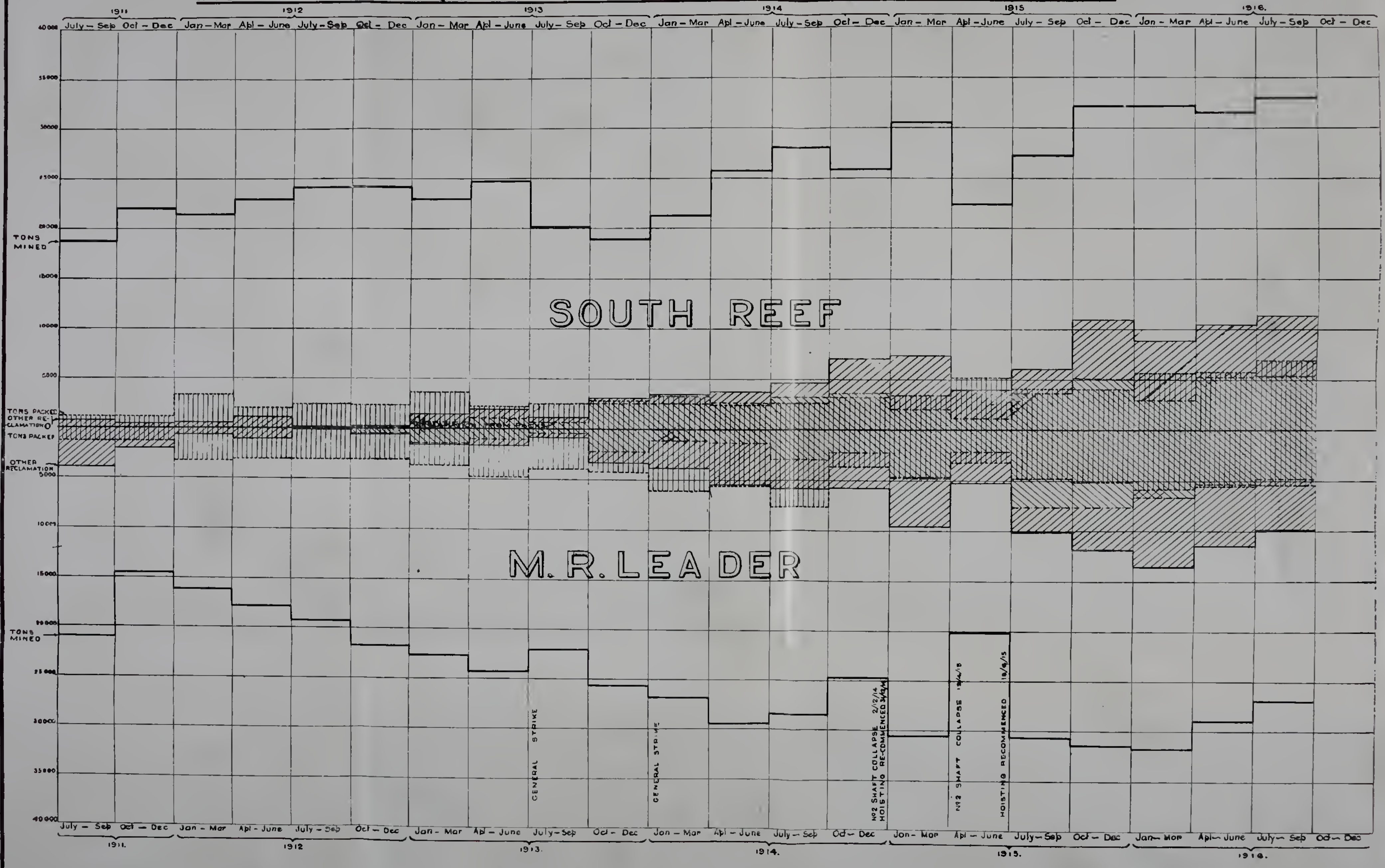


Fig. 13

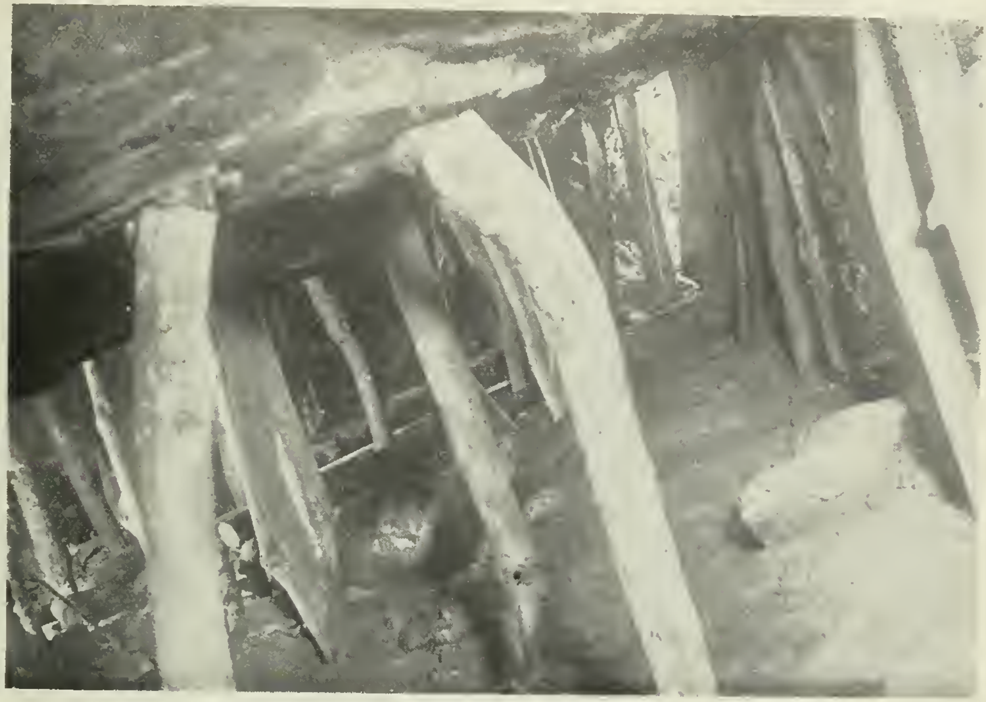


Fig. 11.

Reclamation work, as far as possible, is carried out under the general principle of working from the boundary homewards, but in some cases ribs of unreclaimed packs are left while reclamation work is proceeding nearer home. These are to prevent the hanging-wall caving against the reclamation face, and are also eventually recovered. Reclamation work is greatly facilitated by keeping correct and up-to-date pack plans of the whole mine, the packs being shown on the plan as they are built and marked off when reclaimed.

Conclusions.—Systematic packing saved the current underground workings of the Ferreira Deep and has greatly improved the safety conditions of working. The leaving of reef pillars as a support for the hanging-wall in a mine subject to such pressure as occurs in the Ferreira Deep has proved valueless and most dangerous. The result of pressure on a pillar is shown on Fig. 12, in such a case the pillar itself is a source of danger. The actual effect of the underground conditions at the Ferreira Deep on the cost of working is difficult to determine, as although there is the obvious cost of systematic packing, against this must be set the increased efficiency obtained in stoping where no pillars are being cut, and where the pressure, due to the weight of the superincumbent strata, is used to assist in the actual breaking of the ore. Where packing is done with ore and the packing has to be commenced suddenly on a large scale, the effect on the tonnage mined and on the cost of working is felt until reclamation work can begin to influence the tonnage and costs. It is obvious that when the stage is reached at which a tonnage is obtained from the reclamation of packs in the second working equivalent to the tonnage packed each month in the first working, the maximum tonnage is being obtained with the best costs possible under the prevailing underground conditions, assuming, of course, that the mine has reached a stage about the middle of its life. Fig. 13 shows graphically the tonnage mined, reclaimed from reef packs, total reclaimed and also the quantity of ore packed, in quarterly averages from the inception of the ore packing system on the Deep Section to date. With systematic packing the only pillars left in the first working are those above drives (when the drives have been driven on reef) and these are only left temporarily to prevent stoppages in the tramming. Occasionally a pillar is cut to facilitate the reduction of the stoping width, the pillar being taken out as soon as the new hanging-wall has been supported by packs. The support of the hanging-wall by means of systematic packing, which acts as a cushion on which the superincumbent strata can gradually settle, has also the general effect of reducing to a very great extent the brittleness of what would otherwise be a very short and broken hanging-wall. In a mine where packs are standing, ventilation schemes can easily be arranged, the hoisting conditions are improved by the underground sorting done in reclamation work, and also cleaner mining is done, as less extraneous finely broken waste rock is hoisted.

The good results obtained from the various methods of packing for the support of the underground workings of the mines of the Rand are now becoming more fully realised than formerly, as it is becoming more usual in the mines to find conditions underground approximating more nearly to those which exist on the Ferreira Deep. A point which should not be overlooked, when deciding on the adoption of an ore-packing system for a mine on the Rand, is that once having commenced the packing of ore it is essential that sufficient packing be done to render the reclamation of the packs possible, which cannot be hoped for if packing is at any time curtailed to maintain uniform monthly outputs.

Fig. 12.

In order that others may benefit perhaps in some measure by previous experience this paper has been written. Our thanks are due to Mr. Percy Cazalet for valuable suggestions, and to Messrs. Spicer, Robinson, and Harrison for the drawings and some of the photographs.

For the complete understanding of this subject this paper should be read in conjunction with a paper entitled "Notes on the Support of the Underground Workings of the Mines of the Rand," by Percy Cazalet, which is purposely published in this *Journal*, the two papers being complementary to each other.

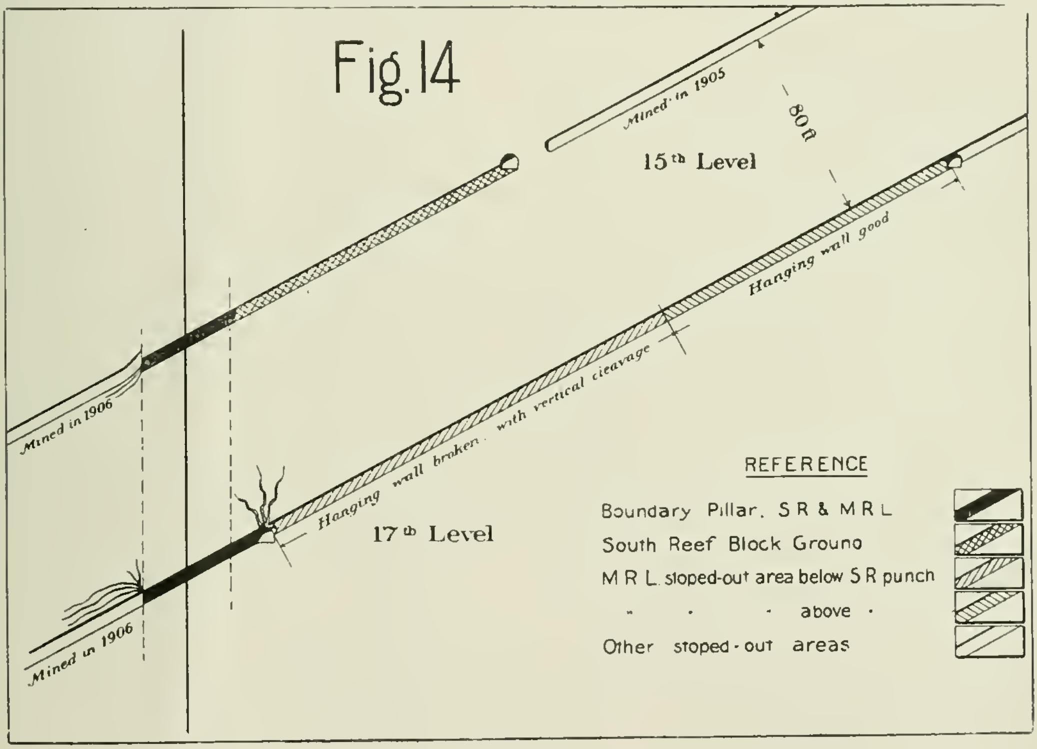


Fig. 14.

APPENDICES.

Appendix No. 1.—The following is an interesting example of the results of pillars punching. Prior to the amalgamation of the Ferreira and Ferreira Deep properties, a boundary pillar, 30 ft. in width, was left in the South Reef and the Main Reef Leader, between these two mines 15 ft. being on either side of the boundary line. The South Reef was left *in situ* from below the 15th level for about five years after it had been stoped out above that level, as shown on Fig. 14. The Main Reef Leader between the 15th and 17th levels was mined two years before the South Reef below the 15th level. This South Reef block had therefore time to act as a punch, and caused a distinct change in the nature of the hanging-wall in the Main Reef Leader stopes between the 15th and 17th levels—the hanging-wall in these stopes being good to a line parallel with the line of strike about 110 ft. below the 15th level—below this line the hanging-wall was very ragged and had an induced vertical cleavage. Eventually when the only Main Reef Leader left *in situ* was that below the 17th level, very distinct cracks appeared passing up through the hanging-wall along the south side of this level, the pillars on the north side of the level burst out and were replaced by packs and the whole of the level setted with very heavy timber which required constant renewal. On the south side of the South Reef boundary pillar stoping was done four years prior to the stoping on the north side of the pillar, with the result that the south side of the pillar has been punched two feet into the footwall, while the hanging-wall remained
]

quite sound, the opposite effect was produced south of the boundary pillar in the Main Reef Leader, where distinct cracks were induced parallel and close to the pillar, causing the hanging-wall to cave. Two years after the South Reef above the boundary pillar had been mined, when sand-filling operations were in progress in the stoped-out area, it was noticed that the water from the sand-filling drained through the cracks in the South Reef footwall into the 17th level Main Reef Leader. Fig. 14 shows more clearly, perhaps, the various effects of the punching action above described.

Appendix No. 2.—Numerous modifications of the general method of packing and the uses to which the modified systems can be put can be easily imagined. For instance (a) on the Robinson Mine, in 1911, approximately 120,000 tons of Main Reef were broken and packed in scattered packs in order that at a later date it would be possible to return and reclaim this low grade reef as well as the Main Reef areas left unmined between the packs. (b) In the upper levels of the Robinson Mine, where the dip is steeper than 35°, it was found possible to stope the Main Reef under a parting of as little as 30 in. by building in rib packs of broken Main Reef, which were extracted at a later date. In these cases the overlying Main Reef Leader had been stoped approximately twenty years previously and many of the stopes had been reclaimed only a few years prior to the starting of the mining of the Main Reef under the parting. This system worked well in dips varying from 35° to 55°.

Mr. Percy Cazalet *(Member)*: Members will note and probably regret an absence of detail in the two papers just read, notably on the question of cost of packing. These omissions are intentional and not accidental, for two reasons:—

(1) It is impossible to discuss questions of cost fairly without also knowing the conditions and being able to assess the countervailing advantages in £ s. d. at the same time: this would have introduced a flood of detail.

(2) It was especially desired to direct the discussion and criticism which these papers, in view of the importance of the subject dealt with, ought and, I hope, will originate, to *essentials and the main point of the necessity for supplying support* CONTINUOUSLY *and* IN TIME *and* BEFORE *this becomes essential due to dangerous conditions developing.*

Such data as is necessary can be supplied in the answer to discussion which will wind up the papers.

The reasons for reef packing being dealt with in detail in the complementary paper are that this system is as yet strange and out of the experience of many on the Rand, and that it has already actually succeeded in dealing with exceedingly dangerous conditions in a safe and efficient manner. No claim is made that this is the *only possible* way of meeting similar conditions of danger and enormous weight, but we do claim that it is the only practicable way which was economically possible in the case of the Ferreira Deep, and probably in a number of other mines on the Rand which must expect and should anticipate similar behaviour of the formations.

Personally, I know of no other method which would fully have met the conditions at the Ferreira Deep and other mines using reef packing, but if others should be devised and applied, it is essential that they allow of immediate, general and continuous support, applied within as little as 10 ft. of the current face, and never leaving any openings between support in the stoped-out areas of as much as 20 ft., or it will fail to meet the conditions of the future, which we *must* expect and anticipate.

The following is a list of mines using continuous packing, which list is probably not complete:—Reef packs and waste packs: Ferreira Deep, Robinson, City & Suburban, City Deep, and the E.R.P.M. Waste alone: Modder B.

Mr. Percy Sherwell regrets his inability to be present this evening, and informs me he is entirely satisfied that reef packing is essential on the City Deep. The squeeze is so great that from 50 odd inches stopes so packed have squeezed to 36 in. in from nine to twelve months, but the ore has been successfully recovered and the areas permanently filled with sand.

You have now a full description of what is meant by the reef packing system to which I referred, as, to my mind, the only remedy yet discovered for really heavy ground on the Reef. I do not say it is going to be the only remedy, but it is the only one yet known.

I hope we will get a full discussion, and that some of those who have had an opportunity of working with the system will give their experience.

The Chairman: I am sure you will accord a most cordial vote of thanks to the authors of these two complementary papers. My ignorance of the subject prevents me from passing any technical comment upon either paper, but I would like to say that both have fascinated and interested me immensely, and I am sure that other laymen who may be present will have thoroughly enjoyed such a clear and concise introduction to the subject. To mining men the papers present in concrete form a very important subject for consideration and discussion, and I hope those with experience of the subject will open a valuable discussion of the papers.

I have much pleasure in moving a most cordial and hearty vote of thanks to the authors for their papers, for the immense amount of trouble which they have taken in preparing the excellent plans and photographs which accompany the papers, and for the very clear way in which they have presented the subject matter to us. I will ask Mr. Kotze if he will kindly second the motion.

Mr. R. N. Kotzé *(Member):* I have much pleasure in seconding the vote of thanks to the authors of these two papers. I came, not to speak, but to listen and to learn, and I have listened, and I hope I have learned something from what I have heard to-night. It will give me great pleasure to peruse these papers at leisure and get further knowledge from them. I think these two papers are of very great value, and I trust that there will be a very large discussion upon the various points raised. I would like to suggest that the discussion be not confined to the particular methods of supporting hanging indicated in the papers, but be extended to the methods that are in vogue on other mines, methods that have contributed largely in the past and will, I hope, contribute more largely in the future, to the safety of workmen. Mr. Cazalet has drawn attention to the increased safety that has resulted from the adoption of the method in the Ferreira Deep and other mines.

One of the principal things to which we should pay more attention here is this question of safety against falls from hanging. It is no credit to us to indicate year by year the number of deaths due to falls from hanging, which, from that cause alone, is nearly as much as the whole death rate from accidents in the best regulated European countries, and more than half as large as the Australian death rate, where metalliferous mining is, as in South Africa, also more extensive than coal mining. I have dealt with the subject from time to time in my Annual Reports; I continually harp on the same theme, and I am very glad that the combined Societies have come forward, and that papers of this merit have been produced. Personally, I shall watch the further discussion of these papers with very great interest. I think the more light we can thrown upon the subject the better. The more people think of these things and act on the suggestions they pick up, the better it will be for us in the future.

A cognate subject which seems to me to have some bearing is the question of subsidences, as to how far the surface is affected by these falls, not so much by the falls as by the settling down of the ground. Mr. Cazalet has indicated that we have had the surface affected at points 1,500 ft. above the point mined. Up to that depth, we are certainly not safe. The question is of importance, of course, in securing surface structures, such as buildings and mine plant and also for the safety of railways. I have had to give particular attention to the matter in the past, and I should like to hear some discussion on the subject if possible.

I would like to have had the opinions of the authors on the question whether the method adopted at the Ferreira Deep has had the result of minimising shocks. It is still a doubtful question whether shocks originate also from the subsidence of large masses of ground, without the bursting of pillars. We know that the bursting of pillars is the cause of violent shocks; for instance, the bursting of a pillar near the shaft of the Ferreira Deep was the cause of the most violent shock we have ever had. I have heard it said that it was the effect of the shock, but, in my opinion, it was the immediate cause of the shock, the primary cause being of course the pressure due to weight.

Mr. Cazalet has already indicated that the method he suggests is to be adopted in areas which are very largely mined out, and so are not applicable to most of the areas in the Far East Rand, for example; but even there I think a little more light on the subject would be useful. We have had mines in the Far East Rand where, even in comparatively small areas, the hanging has come in to such an extent that stopes have been lost. I dare say many members present will have knowledge of such occurrences, and their experience in those areas will be useful.

It has given me very great gratification to come here to-night and listen to the papers, and I shall follow the discussion with great interest.

Mr. C. D. Leslie *(Member)*: I would like to say that these papers have come forward at a very opportune moment. One of the greatest problems in deep level mining will be the support of mine workings. If it were not for the reticulation of dikes throughout our measures, in which Nature has been very good to us, our difficulties would have been very much greater than they are to-day. Over large areas in the Far East Rand we have ribs of rich reef alternating with ribs of unprofitable reef which are left unmined and act as supports, almost as do dikes. Notwithstanding that, it appears, as one gets deeper into the ground, the more one finds that falls of hanging wall are very local, and that the "hanging" breaks away in patches probably on account of the increasing brittleness of the rock and the greater pressure per square inch as greater depths of mining are reached. In deep level mining one can never say when we are protected even by dikes or by ribs of ground, by large areas left intact, or by pillars. I think we can all cordially agree with the authors of these papers that we must protect every step of our journey in deep level mining. I think we ought to be very grateful that the subject has been brought up, and I, like others here to-night, will follow with interest the discussion which will ensue.

Mr. E. C. J. Meyer *(Member)*: Some three or four years ago, on the mines of the East Rand Proprietary group of mines, I was faced with some difficult questions with regard to falls of hanging, as pressure bursts were of frequent occurrence, and it seemed very difficult to find any suitable means of preventing them and the accompanying falls of rock. I had the good fortune to be invited by Mr. Cazalet to inspect the reef packing system at the Ferreira Deep, of which invitation I availed myself. Modifications of this system were applied to these mines with considerable benefit and advantage to the underground workings, the accident rate from falls of hanging being considerably reduced.

I may here state that the problem on the East Rand Proprietary Mines is somewhat more difficult than in most mines, because of the steepness of the strata which averages 48°. It was often found impracticable to build reef packs on this pitch, and square timber packs had to be resorted to. Ordinary blue gum timber is sewn up into 6 in. × 4 in. × 6 ft. and 8 ft. long, and packed into square hollow packs. There are several places in the underground workings where large and extensive subsidence of hanging can be seen resting entirely on these packs and still allowing admission into the stopes in which these subsidences have taken place.

As regards the effect of this system on the stoping efficiency, I quite agree with Mr. Cazalet that a considerable increase in breaking efficiency has been possible, amounting from 10% to 20%, and sometimes even as much as 25%. To my mind, the most notable feature accompanying this system is the smaller consumption of explosives. Before the adoption of this system, owing to the very hard nature of the reef in this particular locality, blasting gelatine was universally used, but since its adoption no blasting gelatine has been used in stoping, gelignite having been found sufficiently strong for the purpose.

I would like to take this opportunity of thanking Mr. Cazalet not only for his paper to-night, but also for giving me this information when I was much in need of it, some three or four years ago.

Mr. Palmer Carter *(Member)*: I think it may be said that the subject of these two papers is a very weighty one in more ways than one, and about the weightiest subject we shall have in mining in years to come. I am specially interested in the papers, as I happen to have been connected with all the mines mentioned, starting at the Ferreira Deep in 1897, when we had no 'weight,' and no one in those days thought we were going to have any. Since then we have found that gravity, even at this end of the Southern Hemisphere acts sometimes. In the case of the old Robinson, it is a coincidence that to-day is the day that the mine was estimated to be finished,—the 30th June, 1917. If some systematic system of packing had not been introduced and kept up in that mine we would have been finished before this date, but, from present indications, I think it may finish on the 30th June later on, but I would not like to say the year. This system is especially useful in a mine like the Robinson, because, in the first place, we have no block ground left in the mine at all, and our task is working an old mine over again, a great part of which caved before its re-opening. We can certainly say we need a system of support under caved ground, supports which are very close together. On the Robinson at the present time we have no working place in the mine over an area of 500 square feet, unsupported. That is our maximum area unsupported.

I would specially like to congratulate the authors for bringing out these papers, which are, I think, the most interesting we have had for a long time, the discussion on which should last for a good many months. The time has, I think, arrived when we should hear of no more cases on the Rand of big falls of hanging, with many casualties, although the hanging *sounded* all right. The only way to make hanging "safe" is to put something efficient under it to hold it up, and I think that is being gradually realised on the Rand to-day.

Mr. J. E. Healey *(Member)*: I am very pleased to be able to thank the authors for bringing their papers before us. It is a subject which has interested me for a number of years. I have not personally visited the Ferreira Deep, where the particular system described has been carried out, but I have evolved a system of systematic packing in the particular area of the Consolidated Main Reef mine, in which I am working. On the West Rand we are not, I believe, so badly off with regard to 'weight.' When I say badly off, I ought to qualify that by saying that we are actually *using* 'weight,' for, if we can control the 'weight,' as Mr. Cazalet has pointed out, we are the gainers. The whole system is not to hold, but to control the hanging. That is what we are attempting to do in some sections of the West Rand to-day.

Mr. Percy Cazalet: I would be very glad to hear the views of those who have visited the particular systems which have just been outlined. There are, I believe, two or three Inspectors of Mines present who could give us their views, and who may not have an opportunity later. I think Mr. de Smidt and Mr. Marquard are present, and Mr. Carty, one of the Workmen Inspectors is also here, and I should be very glad to hear their views.

Mr. S. de Smidt *(Visitor)*: The means of supporting hanging has particularly interested me since the beginning of 1909, when on the Robinson Deep. We then found this pressure of the hanging troubling us very much. Stopes were caving in, and we were losing stope faces week by week. We thereupon started a system of pig-styes, putting them in fairly regularly, and we then found the trouble decrease, until, after we had the system in force for about two or three years, we found that we were seldom troubled with stopes caving in. The difficulty then was the drive pillars punching into the hanging and bursting out into the drives, causing accidents and stopping work. Pig-styes were then substituted for the drive pillars with considerable benefit, and we found that the hanging in the drives, instead of breaking up and our having to have men continually trimming it down, remained good, thus diminishing our troubles very greatly.

Mr. Cazalet made the remark that he thought reef-packing as practised on the Ferreira Deep was the only system considered efficient. There are some mines on the Rand to-day, notably the Main Reef West, the Robinson Deep, and the City and Suburban, that have adopted for some years now a system of pig-stying, and leaving no pillars, and I think that the experience of these mines has been that they have been able to control the hanging to a very considerable extent. Where there is a large reef width, as on the Ferreira Deep, I admit that the practise of pig-stying becomes somewhat difficult, in one respect, namely, the obtaining of sufficient waste rock for filling the pig-styes, but on mines where there are only a few inches of reef there will, as a rule, be plenty of waste rock for that purpose. There will then be no necessity for going back afterwards and re-claiming the packs. I think it is a subject that is certainly very interesting to mining men, and will become more and more so as time goes on, and our thanks are due to the authors of these papers for their remarks on this very interesting subject.

Mr. Percy Cazalet: If we are not having any further discussion to-night, I would like to say a few words before we close. Mr. Kotzé has raised the point as to whether earth tremors are increasing or decreasing at the Ferreira Deep since the discontinuance of the cutting of pillars. There is no question but that they have increased very materially. We have had periods of quiescence and periods of very active business on the part of earth tremors, but there is no question that the general result is that they have increased very materially; that is, the fewer the pillars the more tremors we have had. Of course those who have had a great deal of experience on the particular spot where you have the greatest 'weight' on the Rand to-day, which is centred around the Ferreira Deep, the Robinson, and the Robinson Deep, are satisfied that earth tremors are the 'cause' and not the 'effect' of the bursting of the pillars. I know we are at variance with the view expressed by the recent Commission, but I notice that in the view given, the Commission hedged and included what we are sure is the main cause, as a possible auxiliary cause.

There is no question that once you get 'weight'—and by 'weight' I mean something reasonable in the way of weight, and not just local weight through the scaling and peeling of the hanging wall—once you get 'weight' there is nothing that human ingenuity can do to *resist* settlement, although it can be controlled and limited, and the sooner we give up that notion in mining the better: to prevent subsidence in such cases is a physical impossibility. We all recognise this fact of course, while in practise the knowledge is not always acted up to.

Mr. de Smidt in his remarks mentioned the success obtained by the use of pig-styes on several mines, and there is no question that they are most adequate for conditions suited to their capacity. The City and Suburban gained great advantage from them, there is no doubt, since it discontinued cutting pillars and used pig-styes, but it has been found, with the increase in depth and the increase in weight that it has had to come to reef packing or risk collapse. In the upper levels pig-styes were satisfactory, but they are no longer adequate in the lower levels where the weight has increased. The weight conditions are gradually increasing in the Central Rand, and the sooner we recognise that these conditions will spread to all these mines, and that no mine is going to be isolated from the effects of 'weight,' the sooner we will get on to a proper basis of protecting ourselves against the effects of settlement.

The Chairman: Before we leave, I would just say the papers will be printed in the *Journals* of each of the two Societies, and the authors, I understand, will reply to the discussions of both Societies at one and the same time.

Mr. R. N. Kotzé: I hope in the discussion which will ensue, we shall not only have the great lights of the Mining Industry shining in the discussion, but the lesser lights as well. We would like to hear the opinion of Mine Captains and other underground workers, who, I think, can tell us a great deal about the support of hanging that we do not know.

Mr. Percy Cazalet: There are a number of visitors here to-night who have, perhaps, for the first time attended any meeting such as this, and I would seriously call their attention to what they are losing by not being members of one or other or several of the technical societies on the Rand. The advantage to the individual is enormous. The mere fact of rubbing shoulders with other people in the same profession is a great advantage: the *Journals* are exceedingly valuable, especially to beginners in any branch of science and technology and, in my opinion, it would be a very sound thing for them to consider the advantages to be gained by joining the Societies. Most of them offer possibilities of membership at very reasonable terms indeed: the subscriptions are quite low in some of the more junior branches; there are Studentships and Technical Associateships and positions of that kind in the different Societies, so that the privileges can be obtained at a very reasonable cost, and I would seriously suggest to those present who are not members of any such Societies, that it is in their own interest to join.

Prof. J. A. Wilkinson proposed a very hearty vote of thanks to the Chairman for presiding, which was briefly seconded by Mr. H. A. White.

The Chairman: It is quite unnecessary to thank me for occupying the chair tonight. My duties have been extremely light, and it has been a great pleasure to me to preside over this joint meeting. I appreciate very highly the kind remarks which have been made, all the more so as they have come from representatives of the Chemical Society to myself as, for the moment, representing the Engineers.

The meeting then terminated.

Correspondence and Contributions.

NOTES ON ORE TREATMENT OF PILGRIMS REST ORE.

The following is a recent analysis by Mr. Andrew F. Crosse on current ore:—

	%
Ferric oxide	40·67
Copper	0·20
Alumina	6·60
Carb. calcium	5·16
Carb. magnesium	2·71
Silicious insoluble residue ...	37·70
Moisture	6·90
Loss	0·06
	100·00

There was no sulphur, that is, no iron or copper sulphides, nor was there any arsenic or antimony.

Robert Lindsay.

Review.

ELEMENTS OF PHYSICAL SCIENCE.

Edited by Wm. Briggs, LL.D., M.A., etc. 7th Impression, 3rd Edition. London: University Tutorial Press, Ltd., 1917. 168 pages. Price 3s.

This book, which is, according to the title page, specially prepared to meet the requirements of the Matriculation and Junior Certificate Examinations of the Cape University, has already reached a third edition and, therefore, presumably has met the wants of those who have been required to use it for this purpose. It emanates from a press, which has deservedly got a good reputation for standard text books, and this book is well up to that standard. The methods of experiment, which form the basis of all scientific instruction, are clearly described, and undoubtedly the wide experience gained in using the book for class work has gradually led to the elimination of inaccuracies. In a book of this character, however, we are of the opinion, that every care should be taken to make everything as nearly perfect as it is possible to make it, since this is for the most students the commencement and foundation of their science work. A perusal of the book shows that there is still room for improvement in this respect. The method of preparing phosphorus given on page 82 is obsolete, and should be omitted. Also, would it not be better to state the capacity of flasks in terms of the litre rather than to use the English measure of (fluid) ounces? In South Africa a student is often compelled to place a greater reliance on his text book than is the case in European countries, and this is another reason why the information he derives therefrom should be exact, accurate and up-to-date. Generally speaking, we can heartily recommend this work.

J.A.W.

Notices and Abstracts of Articles and Papers.

MINING.

Ventilation on Witwatersrand Mines.—The Sub-Committee of the Association of Mine Managers dealing with this subject reported as follows:—"The question of ventilation, so far as underground workings are concerned, is purely a mining one, which is influenced by the methods of working, and each mine must be taken on its own merits, as it is impossible to generalize; consequently this Sub-Committee feels that it can only emphasise a few points and make a few suggestions that may be of use to members whose experience, so far, has not brought them into close touch with the question.

1. Shaft area and shaft friction are very important factors in ventilation, and a small error in the fixing of the shaft dimensions may result in the shaft friction absorbing the greater part of the ventilating pressure. The question is affected materially by the number of splits, angles, leakage, etc., all of which have to be taken into consideration. The practical test of a well-ventilated mine is the condition of the atmosphere throughout the mine where men are at work.

With the existing appliances, it is an easy matter to get large volumes of air down a mine, but to ensure that throughout an extensive mine every individual shall be surrounded by a healthy atmosphere requires the mine to be laid out from the very beginning with this object in view. It has been suggested that, in the case of a Witwatersrand mine, where very high air velocities are dangerous on account of the dust that they would stir up and carry along, instead of one large fan at the surface, a number of smaller fans might be installed at different parts of the workings. The system of putting a fan at every level to ensure that each shall receive its correct proportion of fresh air, would have some advantages, providing the increased probability of short circuiting could be overcome.

2. A fan should at all times have as free a discharge as possible.

3. In Witwatersrand mines the fan should be stopped at regular intervals to enable the blades to be cleaned, as they frequently pick up a large

amount of "furring," which adheres to the fan blades and seriously impairs the efficiency of the fan.

4. It is good practice to have a recording ammeter on the fan circuit, so that a continuous record is kept of the hours of work.

5. Door frames and stoppings of brickwork are found in practice to be more permanent than timber, consequently cheaper in the long run.

6. In downcast shafts the timber dries out very rapidly This can be remedied by the use of sprays and atomisers.

7. Where a mine is fan ventilated the air velocities should be kept sufficiently low by means of the necessary splits to prevent the stirring up and carrying along with the current of any dust that has previously settled.

8. Wherever the air velocities are unavoidably high, the floor, sides and roof of the air passages should be kept continuously wet, so that no dust can be derived and put into circulation from this source.

9. It is sometimes advisable in a mine that is fan ventilated to stop the fan or fans for a short period at blasting time, in order that those employed in lighting up charges may not be overtaken by smoke and fumes before they reach the stations.

10. In arranging a fan chamber, it is desirable, where possible, to keep the motor out of the direct passage of air to the fan, as on account of the large amount of dust in such air after blasting it is difficult to keep the motor clean and efficient.

11. The above is also very necessary as it provides a place for the fan attendant to sit, which is not in the main air-way. It is further advisable, if the fan attendant cannot reach the clean downcast air readily, to provide a small cabin for him, equipped with a compressed air jet, into which he can retire while the smoke and dust from blasting are passing the fan. In cases where the clean downcast air is near to the fan, the fan attendant can, and should, retire to such a place until the condition of the mine returns to normal."—Appendices to Reports on Time and Labour Saving on the Mines.—Association of Mine Managers of the Transvaal, November, 1915. (G. H. Sm.)

MISCELLANEOUS.

THE INDUSTRIAL RESOURCES OF SOUTH AFRICA.—"Some valuable evidence was given before the Select Committee on Food Supplies, Industries and Technical Training by Mr. Herbert Warington Smyth, M.A., F.G.S., M.I.M.M., Secretary for Mines and Industries, who, in outlining the organisation of the Industries section of the Department, said: The Industries section at the present moment consists of principal clerk and staff, who are dealing with ordinary industrial questions, and are also in charge of the work connected with the recommendations for the issue of priority certificates by the Minister of Munitions in the United Kingdom in connection with the war. The work is all under the Controller of Imports, and for that purpose I am Controller of Imports, and I have an Assistant Controller. We work through local committees. The ordinary work of the Industries section is occupied with general trade matters, and in that connection we are in close touch with the Trades Commissioner in England, with the High Commissioner, and with the Imperial Institute. The Imperial Institute has been of great assistance as regards investigations of a more or less scientific kind, giving us information regarding products from South Africa. The Trades Commissioner communicates with the Industries Department in regard to a number of questions, thus keeping in touch with producers in this country. Weekly statements of exports from the Union are sent to the Trades Commissioner, and he arranges for their publication when he considers necessary on the other side for the information of purchasers. The Industries section of the Department of Mines and Industries is also acting in conjunction with the Director of Census, in regard to the census which is now being made of our industries under the Statistical Act. We hope to get the forms out in June, and to have the figures available in September next. The Industries Advisory Board is the first of the two committees which have been appointed. In addition to that already mentioned, the department has also had to deal with the following works, viz.: questions regarding (1) Industrial disputes; (2) Trades Union regulations; (3) factories; (4) workmen's wages protection; (5) workmen's compensations, etc.

Those were the subjects that we dealt with during 1914, which brought us from the point of view of merely dealing with labour, into close touch with the general industrial questions, and these were the subjects which were then before us. Then coming to the Industries Advisory Board, as a result of the representations made by the Imperial authorities that efforts should be made in the Dominions to investigate the raw products and industrial resources of the various Dominions this committee has been appointed on somewhat analogous lines with those which have been created in Canada, Australia and New Zealand, to advise Government on the best methods of encouraging industrial development. The members of this Advisory Board are as follows: Messrs C. G. Smith (Chairman), G. A. Kolbe, W. J. Laite, E. Chappel, W. G. Nicholson, Sir Thomas Collinan, W. R. Jackson, Professor G. H. Stanley, J. Pyott, and A. J. Chiappini. Their duties are to advise the Minister on industrial matters generally, with a special view to the encouragement of industries in the country. The principal subjects referred to them in the first instance, as showing the class of subject dealt with, were as follows: (1) Adulteration of leather; (2) diamond cutting; (3) the manufacture of an industrial alcohol as a substitute for petrol; (4) questions regarding production of timber as well as of scientifis research with regard to industrial matters; (5) tobacco sheep-dip; (6) fertilisers; (7) farm foods; (8) coach-building industry; (9) prohibition of export of scrap metal; (10) statistical census; (11) Customs classification for statistical purposes; (12) Factory Bill (13) appointment of a Trades Commissioner to visit East Africa; (14) encouragement of food production in the Union and the further consideration of certain matters discussed at previous meetings. These are subjects which have already been dealt with by the Board since their first meeting in October, 1916. Then special action has been taken, on the recommendation of that Board, in certain directions, viz.: (1) The creation of a Scientific Advisory Committee and the appointment of a Scientific Technical Adviser; (2) action with reference to making available industrial alcohol; (3) recommendations regarding adulteration of leather; (4) putting into force of the Statistical Act in regard to industrial production; (5) prohibition of export of scrap metal; (6) the appointment of a Trades Commissioner for East Africa; and (7) encouragement of food production in the Union.

The Industrial Board has found, as has been found in Great Britain and other Dominions, that a committee consisting of business men, with one scientist (Professor Stanley) in this case, was naturally unable to give opinions on a large number of scientific subjects, which, in a country of raw products and undeveloped resources such as ours, naturally arise dealing with the question of the development of industries, and they have recommended the appointment of a Scientific Committee to advise in regard to the scientific aspect of the development of industries. The Committee was recently appointed by the Government. I may say, before going further, that the scientific societies of this country, especially the technical societies on the Rand, which include members in all the Provinces of the Union, had already made proposals to the Government for the appointment of a committee of this, and had practically offered their services free—at all events, without remuneration, in order to try and assist the investigation which they feel is necessary, and the Government, taking advantage of that, have appointed a committee as follows: Mr. J. Burtt-Davy, F.L.S. (Biology), Mr. L. Colquhoun, M.A.C.S. (Chemistry), Professor D. F. Malherbe, M.A., Ph.D. (Chemistry), Professor B. De St. J. van der Riet, M.A. (Chemistry), Professor Orr, B.Sc. (Mechanical Engineering), Professor Young, F.R.S.E. (Geology), Mr. W. A. Caldecott, D.Sc. (Metallurgy), Professor J. C. Beattie, F.R.S.E., D.Sc. (Physics), and the President of the Royal Society of South Africa (*ex officio*).

That committee is a fairly representative one of all the sciences. They sat last week in Capetown, and have done a considerable amount of preliminary work. The whole object of the committee is to deal with questions regarding research and investigation of the technology of our industries, and their scientific aspect. The actual method of administration in this direction is rather novel in all countries. So far it is only an Advisory Committee—so far they have only advised the Industries Board in what direction it should institute activity. I will give the general conclusions of the committee, as shown in their resolutions. They say that in view of the urgent necessity for an economic survey of the natural resources of the Union, as a preliminary measure, special reports should be prepared by the authorities on a number of subjects. They consider than an indispensable preliminary to any kind of scientific research is to find out, and collate, all available information on the questions to be dealt with. We have an immense amount of scientific information; it is stowed away in libraries and pigeon-holes, and elsewhere, in places at present inaccessible, and hardly anybody knows where to get at it. We have a certain number of experts on all these subjects, and by getting these men to work on the matter, and to write bulletins in connection with these subjects, the committee thinks we should be able to get a vast amount of scientific information together, which will show us at what points the scientific investigation ought to commence. For instance, there is a question of material for fertilisers available in certain districts. Various authorities have investigated, in different districts, on this matter, but the whole things has never been put together and collated by an expert authority, and the consequence is that such information remains in a detached condition; nobody is dealing with it specifically. The Agricultural Department is dealing with it to a certain extent, and we are dealing with it to a certain extent, but it is nobody's business, and the first preliminary, in the opinion of the committee, is to get a statement of the whole position, and to deal in a similar manner with a number of other subjects. Secondly, they recommend that fees be paid to reporters on the subjects named; such fees will come out of the vote for scientific research. The third recommendation is that these reports are to be published in an industrial journal, and reprinted as bulletins. This means the issue of an industrial publication, and a small bulletin form should be issued by the department, with one, or two, or more of these reports, as they come in. They recommend here that 48 subjects should be investigated by special experts, as a preliminary investigation of all our raw material resources in the country, and of course there will be later on all these reports coming in, probably at the rate of six or eight a week, and for a time it will be necessary to publish the journal two or three times a month, with several of these subjects in it. After that the publication will come out monthly, or quarterly, as the case may be, as we get further information from time to time which is of value. That will come afterwards; we are only feeling our way in the matter at present. Dr. Caldecott, of the Goldfields, is acting chairman of this committee. He is a very able business man, as well as of acknowledged scientific eminence. The fourth recommendation of the committee is that the editor of the journal is to be a member of the staff of the industrial section of the Department of Mines and Industries. That is to say, the idea is that one of the scientific staff should edit this publication, and that it should be done in the department as these reports come in. Now, as to what extent the committee will advise on subsequent steps, these bulletins when prepared by their authors will be submitted to the committee, who have among them mechanical experts on each subject, and will be initialled by the chairman. If any necessary amendments or alterations are considered desirable, they will put forward these suggestions to the author, but they will not be published until submitted to the committee. I have a list of subjects on which reports are to be obtained.

(1) Inorganic chemicals: (a) Hydrochloric acid, (b) common salt, (c) carbonate of soda, (d) arsenical compounds, (e) sulphuric acid, (f) nitric acid, (g) iodine, (h) Epsom and Glauber salts, (i) bleaching powders, (j) ammonia compounds, (k) potassium nitrates, (l) plaster of Paris. (2) Certain minerals used in arts and industries. (3) Fish and fishery products. (4) Wool and Mohair products. (5) Hides, skins and leather manufactures. (6) Meat industry, hides, horns, hoofs, etc. (7) Butter, cheese, and other dairy products. (8) Coal, its quality as a raw material for distillation products. (9) Oil shales, mineral oils, and solid bitumens. (10) Base metals and their production. (11) Conservation and utilisation of water power. (12) Iron and steel industry. (13) Olive industry. (14) Silk. (15) Soil conservation, including erosion. (16) Close and ceramic ware: past history, and general prospects. (17) Soap, raw materials and by-products. (18) Lanoline and other animal fats. (19) Tartaric acid and other by-products of wine industry. (20) Native timber trees. (21) Electro-

chemical industries. (22) Review of Government action regarding industrial development by Dominions, and other countries, *e.g.*, Japan, Germany, and United States. (23) Maize and maize products. (24) Cereals, other than maize and their products. (25) Fruit and fruit products. (26) Preparation of foodstuffs, other than meat for export. (27) Vegetable foods, other than cereals and fruits. (28) Sugar and sugar products. (29) Tea, coffee and chicory and by-products. (30) Wines and spirits. (31) Drug yielding and poisonous plants and products. (32) Tobacco and products. (33) Cotton and products. (34) Fibre plants, other than cotton and brush materials. (35) Tanning and dyeing materials, including wattle bark and extracts. (36) Vegetable oils and resins. (37) Rubbers. (38) Cultivated timber. (39) Wood products. (40) Paper. (41) Diseases affecting the development of crops, preventive and remedial measures. (42) Insect pests and remedial measures. (43) Economics or production of staple crops, *e.g.*, maize, beef, mutton, and wool and statistics of farm products and acreage. (44) General review of agriculture, pastoral and forestal possibilities. (45) Barley, hops, and brewing materials. (46) Insecticides, fungicides, dips and disinfectants. (47) Foodstuffs for livestock. (48) Essential oils, including eucalyptus.

I might just give you a further summary of the general conclusions of the Scientific Committee as showing you the methods which they propose to adopt. After dealing with that list of special subjects they recommend the appointment of subcommittees to investigate alcohol and fertilizers. Then they recommend approaching the Government Departments with a request to afford all facilities for research and to furnish all available information to reporters under the scheme, and they recommend the preparation of a census of facilities for investigation or research in respect of (a) available laboratories and institutions, and (b) as regards available staff. They also passed a resolution recommending co-operation with the Native Protectorates and Rhodesia in order to cover the whole ground of the resources of the sub-continent as far as possible; further, notification will be sent to the United Kingdom and the Dominions of the steps to be taken to develop our resources, and asking for information in connection with the points with which we are dealing. Then they also recommend that immediate steps should be taken for a special survey in certain lines now this comes to the scientific work pure and simple, over and above the work in regard to those reports—in connection with (a) geology and special mineral resources. Now it has already been mentioned that a lot of our institutions are overworked: there are certain aspects of our mineral resources which require investigation and the Geological Survey is overworked and under-manned—we have three men full up with important work and they cannot be taken off, so that there we have a bit of a check; (b) botany; (c) water and power; and (d) fisheries. They also recommend the compilation of certain plans and maps on certain subjects for the information of investors and manufacturers later on, showing (a) density of native population for labour purposes; (b) sources of labour; (c) temperature and rainfall; and (d) transport facilities. That is rather more in connection with the details of the work which will have to be investigated later on, and that gives you an idea of what is in their minds. These preliminary surveys or reports will be done by a number of authorities selected for their knowledge on the various subjects for a small fee—I think it will cost about £1,500 in fees for the whole thing, and of course it will have to be a special effort on the part of the Government servants asked to do it. If the results are what we expect it will be money very well invested. Of course we are going to co-operate with the other Imperial organisations, so that in such instances of raw material being supplied by Christmas and Ocean Islands to Japan, Australia and Germany for manufacture into superphosphates and sent to us eventually as the finished product, we shall have an enormous advantage in the direct interchange of information on these subjects. Then of course, we shall want somebody to digest that information. That is the general scheme. Our local scheme under the scientific advisory committee comprises two branches—(1) the actual work of survey and examination, which will fall under a kind of development work, and (2) publicity. As far as we have gone in regard to publicity, I mentioned the proposal of the industrial journal and that should be the means of making public our information, investigations, conclusions and so on. I quite agree as to the desirability of instituting organised educational propaganda in connection with the various enterprises throughout the country, so that the public may become fully cognisant of what is being done, appreciate the significance of the movement, and give it their political support, and in order to ensure that there will ultimately be no opposition to further development on the ground of expenditure. The last point raised, on which perhaps sufficient stress has not been laid, was educational work such as lectures and the publication of technical information and establishment of technological museums in various centres.

To conclude, I might just read over to you the paragraphs which have been adopted as regards the functions of this side of the Industries Department, that is, on the scientific and technical side; that gives you a clearer idea of the co-ordination of all these points we have discussed: (a) in addition to providing for industrial research, the coordination as far as possible of all industrial investigations and research in South Africa and the collection and dissemination of data emanating therefrom; (b) the co-ordination with other Government Departments of the United Kingdom and the Dominions to obtain information already available to avoid overlapping and to take advantage of facilities for research not available in this country. The acquisition and utilisation in arts and manufactures of knowledge already in existence in countries which are more highly developed industrially than South Africa; (c) carrying out an economic survey of the natural resources of South Africa and the furnishing of advice in regard to the best methods of attacking industrial problems for inducing industrial improvements for facilitating and encouraging manufactures in suitable localities; (e) the co-ordination of various industries to obtain combined results and the exchange between user and manufacturer of manufacturing improvements and operating experience; (f) the standardisation of scientific and industrial quantities affecting the efficiency of production and the accuracy of statistics; (g) educational work such as lecturing, the publication of technical information and the establishment of technical museums in suitable localities. Those are the main points in connection with the scientific side of the question."—*The South African Mining Journal*, June 23, 1917, p. 403. (A. W.)

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII. AUGUST 1917. No. 2.

MULE HAULAGE UNDERGROUND AT THE DURBAN ROODEPOORT DEEP MINE.

By A. P. Rouillard (Member).

The lay-out of the underground work at the Durban Roodepoort Deep Mine is such that a large part of the ore mined has to be handled on the 12th Main level. It was decided to transport with mules on this level, until larger tonnage handled would allow of efficient mechanical transport. The level has a grade of 0·08%, which is found a little too steep a gradient for an efficiently laid out and maintained track, as the power required to pull the empty cars is greater than that required to pull out the cars. A grade of 0·066% would be better. The tracks are of 30 lb. rails laid on wooden sleepers. The longest stage for hauling is 1,500 ft. Originally a distance of 2,250 ft. was hauled, but it is found that the efficiency of the mules was better when this distance was halved. The cars used are of 23½ cub. ft. capacity fitted with Rowbotham wheels and fixed bodies. The mules are about 14 hands in height and thick set. Mules of this type are, however, too small, and where drives allow, larger mules should give greatly increased efficiency.

The Durban Deep shafts are of the compound type, so that a special mule skip has to be used for lowering mules underground. A drawing of this skip is shown in Fig. I. One side and the top are opened in order to

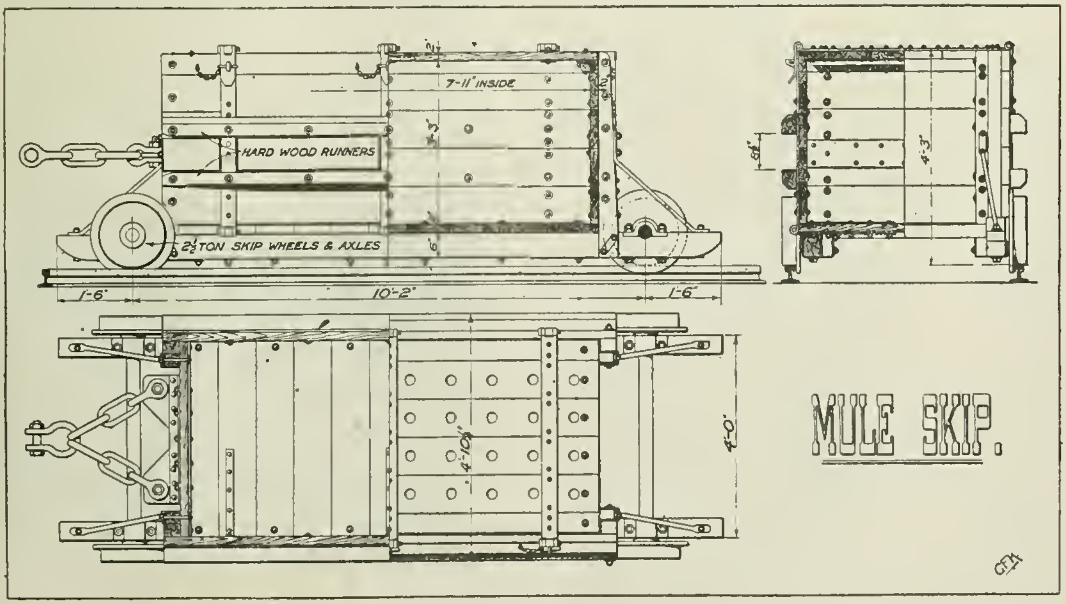


Fig. I.—Details of Mule Skip.

place in a mule, and for this purpose the mule is cast and tied up. The skip is padded inside with sacking and straw, and the mule is placed so as to travel in a sitting position, its head being secured with straps at the top end of the skip. The skip is run on to the track at the surface and off again on to the station where the mule is taken out, the whole operation for one mule taking 50 minutes.

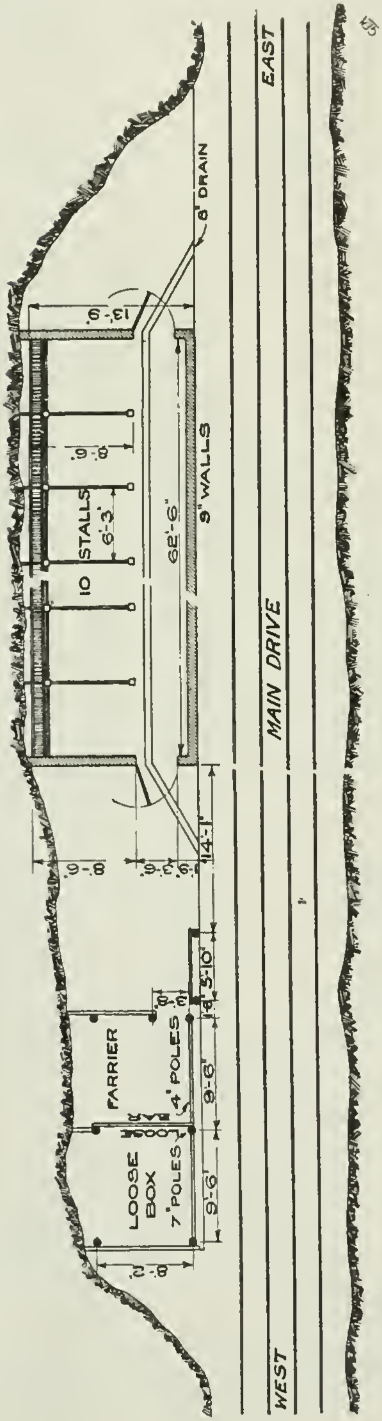


Fig. 2.—Underground Stables (a) Plan.

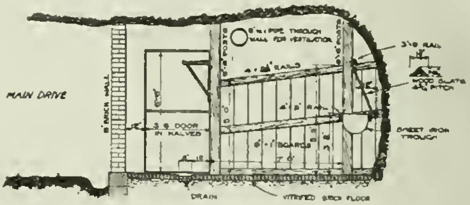


Fig. 2.—Underground Stables (b) Cross Section.

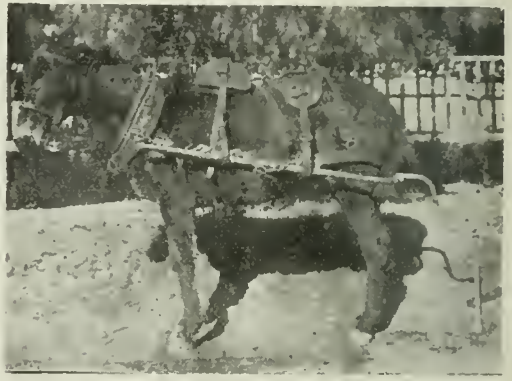


Fig. 3.

Fig. II. shows the arrangement of the underground stable built in the main level, a spot being chosen which required only a small amount of extra excavation, as it was originally required for an extra double

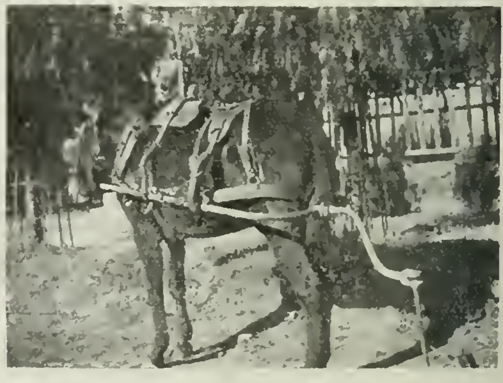


Fig. 4.

parting. The cost of building the stable was £300.

A mule draws six trucks through the medium of harness, shafts and pin, the shafts and pin being shown in detail in Figs. III. and IV. The duty of one mule for a shift of eight hours is over 133 tons, for a distance of 1,500 ft. The cost of tramming 1 ton 100 ft. is, therefore, roughly, 0·046d. The cost of food, attendance and sundry stores for 10 mules for a period of three months is as follows:—

White Wages, Average No. weekly, 1...				£104	17	9
Coloured Wages, ,, ,, 6...				57	2	11
Coloured Labour, Sundries				23	3	6
Workshops				40	7	6
Stores				122	1	11
3,700 lb. Bran	£17	7	8			
3,400 ,, Whole Mealies...	13	1	6			
600 ,, Crushed Mealies	2	5	4			
9,950 ,, Forage ..	33	15	2			
7,700 ,, Lucerne ...	23	15	5			
750 ,, Oats	3	9	11			
200 ,, Barley ...	1	0	0			
250 bundles Green Barley	1	17	6			
3,650 lb Bedding ...	5	18	10			
Brushware	1	3	4			
Canvas	1	9	2			
Candles	3	18	1			
Carbide		14	1			
Disinfectants ...	2	14	7			
Oils	1	17	6			
Soft Soap		3	0			
Sundry Paints	1	16	0			
Harnessware	1	9	7			
Medicines	1	6	0			
White Lime ...		8	0			
Tools, etc. ...	2	11	3			
				£347	13	7

This gives a cost per mule per day of 7s. 7·7d., and the mules keep in excellent condition. As it is now common to use horse or mule haulage on many mines, and as it will become a still more general practice in the future, it is thought that the above notes may be of interest to some of the members of the Society.

A METHOD FOR FURTHER REDUCING CYANIDE AND ZINC CONSUMPTION.

By R. C. H. Cooke, F.C.S., A.I.M.M. (Member).

It is a well known fact that any saving which could be effected in the consumption of such essential supplies as sodium cyanide and zinc would, if the saving could be carried out on all the mines of the Rand, amount in the aggregate to a very considerable figure, both in value and weight, and would therefore be of considerable importance to the mining industry.

That this is realised by all those concerned in the cyanide process is evident by the many efforts that have been made in the past to further reduce the consumption of cyanide, with the special effort made in 1915 by an appointed committee, whose very thorough investigation left no loophole for a chemical solution of the problem.*

The two following quotations are taken from the above paper:—(1) "The results of special efforts made (to effect a saving in cyanide) when the onset of the war threatened supplies, showed a loss of gold more than counterbalancing any saving in cyanide."

(2) "A saving could be effected if lower cyanide strengths were possible without counterbalancing losses of gold in the residues, but this is not generally the case, and the point must be emphasised that any saving of cyanide by means of increased alkalinity or any other way of reducing gas losses must be partly offset by increased amount of loss in residue moisture."

It is a pity in the author's opinion that the details of the "special efforts" referred to were unavailable for inclusion in the paper.

The author does not wish to re-open discussion on the loss and decomposition of cyanide solutions due to hydrolysis, exposure to the atmosphere, fouling, moisture replacement, etc., or the beneficial effect of sufficient protective alkali; but desires to bring before this Society the conclusions he has arrived at from practical experience gained in cyaniding under various conditions on different fields, dating from 1899, when he first worked under John S. MacArthur and also Virgoe, in Mexico. It was then thought quite normal to use a strong solution of 0·45% KCN, with a cyanide consumption of one to two pounds per ton of sand, excluding exceptional mines that consumed five pounds and over per ton.

It has been the author's experience in dealing with ores, refractory and otherwise, to find that the same extraction could be obtained with weaker solutions than those in actual use, but to arrive at the minimum economic strengths, it was necessary to

---

*See this *Journal*, Vol. XVI., September, 1915: "Cyanide Consumption on the Witwatersrand," by H. A. White.

carry out much experimental work in close conjunction with the actual practice. He has found that a weak solution is equally effective in dissolving out the gold, provided that efficient dry leaching be given, but that in using a weak solution *very much closer attention must be paid to precipitation.* Neglect in fully recognising this important fact, or at least by waiting until there can be no doubt about bad precipitation having set in, has probably been the cause of much anxiety and trouble to many who have attempted to save cyanide by this method.

The following data from the author's notes and observations may be of interest, from which it will be seen that much weaker solutions are now in use than formerly.

Year.	Mine.	Strength of Solution used in Sand Treatment % KCN.			
		Strong.	Medium.	Weak.	Slime wash.
1899 ..	Mexico, El. Carmen ...	·45	·12	·10	None used
1903 ...	Mexico, El. Oro	30	·12	·10	
1905 ...	Central Rand	·25	·08	·08	·012
1905 ...	,, ,, ...	·18	·05	·05	—
1916 ...	East Rand	·096	·026	·026	·01
1917 ...	Central Rand	·12	·022	·022	·007

1903.—*El Oro Mining and Railway Co., El Oro, Estado de Mexico.*

200 Stamps plus 20 Huntington Mills.
240 Tons per Sand Charge.

(1)—Preliminary washes given to sand while in collectors:—

40 tons medium wash at ...	0·12% KCN
40 tons strong wash at ...	**0·25** ,,
20 tons medium wash at ...	0·12 ,,

(2)—Sand after transfer to treatment vat received:—

160 tons strong wash at ...	**0·30**% KCN
100 tons medium wash at ...	0·12 ,,
100 tons weak wash at ...	0·10 ,,
100 tons weak and water (as time permitted).	

(Charges leached dry between each change of solution.)

From the above data it will be seen that the tendency has been to steadily reduce strengths of working solutions, and the author fully believes that strengths can be still further decreased without in any way affecting the dissolution of the gold.

On an 80 stamp proposition (the Golden Kopje Mine, Rhodesia), where milling in cyanide solution was carried out, the strength of the working solution was gradually reduced to 0·03% KCN without using any stronger solution subsequently and the value of the residue was not increased thereby. Similar reductions in strength of solution were made with equal success on some smaller properties, including one in the Barberton district; this latter was a very refractory ore, but the cyanide and zinc consumptions per ton treated were reduced from 0·80 lb. and 1·75 lb. respectively to 0·50 lb. and 0·75 lb., and the value of the residue was reduced at the same time. These instances prove that weak solutions are equally as effective as strong solutions in dissolving the gold.

The following two quotations are taken from "Rand Metallurgical Practice," p. 385, chapter on "Chemistry of Banket Ore Treatment," by Dr. W. A. Caldecott.

(1) "The amount of gold an extremely weak cyanide solution can dissolve under favourable circumstances, as, for instance, mill service water contaminated with a little cyanide, makes the maintenance of a much higher working strength for sand solution in practice mainly consequent upon the necessity for securing constant efficiency of precipitation."

(2) "The stronger the solution used the greater the cyanide consumption, owing to its greater solvent action on pyrite and other base metal compounds." Quotation (2) explains why a large proportion of the solid cyanide dissolved in making up strong solutions for sand treatment is consumed before it reaches the heads of the extractor boxes, but if this practice could be altered so that the bulk of the solid cyanide would be added to the solutions at the head of the boxes to maintain good precipitation, as desired in quotation (1), a considerable saving in cyanide would be effected.

Precipitation is considered satisfactory if the solution leaving the boxes contains no more than 0·01 dwt. gold per ton. Bad precipitation may often be remedied by dressing up the boxes, decreasing flow, or increasing the strength of solution temporarily until normal results are again obtained, one or more of these methods being used without worrying about what may be taking place in individual compartments of the boxes. All cyanide managers have experienced considerable variation in quantity of gold actually recovered at successive clean-ups without in any way having changed their method, and quite irrespective of the theoretical extraction. If there is a deficit between the theoretical and actual, the explanation generally is, that the gold has travelled down the box, and will be recovered next clean-up, but sometimes it has travelled down so far that it is not all recovered until at least one or two clean-ups later. From these considerations and the results of his work the author has been forced to the conclusion that, to maintain uniformly satisfactory precipitation and prevent gold leaving the extractor boxes, it is essential to know every day what amount of precipitation is taking place *in each compartment* if a permanent saving in cyanide is to be made by using weaker solutions without causing increased loss of gold in residues. This may at first sight appear to be both a colossal and expensive task, but if the compartments of the various boxes are taken in series, and representative samples only are taken, tested and assayed daily, it is not an impossible one, although it will certainly require the attention of a skilled man and the daily recording of all results. Should bad precipitation be found in any one series the offending compartment must be immediately ferreted out and dealt with. By carrying out this method constantly a startling condition of precipitation will occasionally be detected, but if the remedy be applied immediately the mischief can be stopped before bad precipitation spreads to the bottom of the box.

In properly working boxes under normal conditions approximately 80% of the gold is precipitated in the first compartment: Example I. (see table below); but the author's experience is that 90% can be retained, Example II.; although when the flow is too fast or any other detrimental cause interferes a condition developes, as in Example III., which if left alone rapidly approaches Example IV., and later V.

Solution Value at Head of each Compartment.		1st Compt. dwt.	2nd Compt. dwt.	3rd Compt. dwt.	4th Compt. dwt.	Last. dwt.
Example I. ...	—	3·00	0·60	0·06	0·02	0·01
,, II ..	Stage 1 ...	3·00	0·30	0·03	0·00	Tr.
,, III. ...	,, 2 ...	3·00	1·00	0·50	0·04	0·02
,, IV. ...	,, 3 ...	3·00	2·00	0·75	0·40	0·02
,, V. ...	,, 4 ..	3·00	2·50	1·00	0·75	0·40

The table demonstrates various stages of precipitation in an extractor box of five compartments. If the precipitation continues as in stages 2 and 3 it will help to explain a shortage of gold otherwise unaccounted for at the clean-up, although judging solely by the value of the solution leaving the boxes precipitation may have appeared fairly satisfactory.

It may be noticed that when a lump of cyanide is added to the head of an extractor box whose solution surface is quite placid, within an hour's time a fairly vigorous evolution of hydrogen may be observed (this means good precipitation). This action will slowly travel down the box to the second and then the third compartment, etc., and gradually peter out in the first compartment, until finally, after a fairly constant lapse of time, the surface again becomes placid, and bad precipitation again sets in. If, however, a second piece of cyanide be added before this latter stage occurs, good precipitation will continue. It may be necessary to add a piece of cyanide every four hours, but the period can only be determined by constant sampling and testing until this point is fixed. By this method the bulk of the solid cyanide necessary to keep up the required strength of the working solutions, *will be added to the head of the boxes*, and by close supervision perfect precipitation can be maintained. A further small amount of cyanide would probably be necessary to slightly strengthen the first sand washes, and this should be dissolved just before using the solution. It will thus be found practicable to reduce cyanide strengths of working solutions and, so long as a close watch be kept on each compartment of the boxes, this may be done with perfect safety, provideed that at the least indication of bad precipitation in a compartment the box responsible for this be singled out and dealt with by the addition of extra cyanide, etc.

As it is essential to know what each compartment (or series) is actually doing as regards precipitation as early as possible every morning, the author has found that the "stannous chloride" method is quite reliable, check samples being assayed. By constant handling of this method, taking a litre of sample for test, and with efficient care, a quite extraordinary degree of accuracy can be attained in judging the gold value of solutions (easily as low as 0·02 dwt. per ton). Samples of solutions leaving individual compartments are obtained by using a suitably bent glass tube introduced between the compartments and held well below the surface to prevent any contamination by floating particles of precipitate, the solution being syphoned over into a Winchester bottle.

Daily samples from the solution storage vats should, however, be taken for assay, it being frequently noticed that these samples contain slightly more gold than the solutions leaving the boxes on account of particles of precipitate being mechanically carried over and re-dissolved in the excess of solution away from the zinc. The results of these assays would also be a valuable guide to the efficiency of precipitation as a whole.

The author has experimented with strong solution drips and other methods and places of adding solid cyanide, but with less efficiency. By the improved precipitation resulting from the adoption of the above method it has been found possible to reduce the quantity of zinc shaving in the boxes.

It is a well known fact that during the winter months, particularly on plants where no waste heat is available for heating slime solutions, precipitation is a constant source of worry and trouble, the temperature of the solutions having undoubtedly a great deal to do with the obtaining of satisfactory results.* With heated slime solutions good precipitation can be maintained with weaker solutions and less zinc shavings than with cold solutions. The author would, therefore, like to raise the point whether, waste heat being available and other conditions favourable, it would not pay to maintain the temperature of sand solutions between 70° and 80° Fahr. The many advantages of heating slime solutions are well known, and are of such importance that with waste heat available the theoretical disadvantages are more than counterbalanced. With sand solutions, on the other hand, the apparent advantage would be in assisting precipitation. The publication of data, or at least a definite expression of opinion as to the economy or otherwise of heating sand solutions would be of value.

It would appear that only by some such method as that described in this paper can any appreciable saving in cyanide and zinc be obtained. Assuming that a saving of 0·05 lb. per ton milled of both cyanide and zinc be made, this, on the Rand's annual tonnage of approximately 27,000,000 tons of ore crushed and cyanided, and with the price of these stores at, roughly, 1/- per pound and 8d. per pound respectively would amount to £112,500, equivalent to over £400 per month on a mine treating 100,000 tons. The author hopes that the whole question of strengths of solution considered necessary for satisfactory dissolution and precipitation of the gold on these fields will be freely discussed, and that those who have data on the subject will allow them to be published.

NOTES ON TREATMENT OF PILGRIMS REST ORE.

By Robert Lindsay (Member).

(Printed in Journal, April, 1917.)

DISCUSSION.

Mr. Andrew King *(Member)*: The details of practice and the many unusual features described in this paper should make it of particular interest to those engaged in cyaniding either the comparatively simple Rand ore or the more complex ores encountered elsewhere.

The degree to which fine crushing of the tube-mill pulp as well as the final cyanide pulp is carried, is to be noted—approximately 76% of the ore crushed being treated in the slime plant. It may be assumed that the finely divided condition of the gold, the value and the soft nature of the ore, together account for the production of such a large proportion of slime.

---

* See this *Journal*, Vol. XI., p. 252.

From the flow sheet (p. 167) it would appear that the overflow from the tube-mill feed cone passes direct to the sand spitz. To the writer this does not seem quite a safe practice, in spite of the fine nature of the pulp so passed, particularly as the tube-mill cone is fed direct from the stamp-mill and as a spitzkasten is used for eliminating fine sand from the slime. A description of the washing device used on the slime separating cones would be of value.

In connection with sand treatment, it would appear that the collecting vat (if this is the one referred to as "Top Tank A") is used for part of the treatment as well as for collection. If this is so, then the question arises whether this arrangement does not lead to contamination of the mill water with cyanide solution; the assay of the slime collectors overflow would indicate whether this is taking place. A larger tonnage of precipitated solution from the slime plant as a final wash would probably reduce the cyanide strength of the last drainings (apparently about 0·027 KCN) and would thus slightly reduce cyanide consumption.

In the treatment of the slime the time given for circulation seems short, and the ratio of solution to dry slime seems low when compared with usual Rand decantation practice. Could an equally good result not be obtained with less cost by increasing the time of circulation and the solution ratio, and by decreasing the number of transfers and the number of solutions in use? The method described of clarifying solution from the slime plant is unusual: cocoa matting *per se* is anything but a good medium for filtration, and one must assume that cloudy solutions and badly settled slime charges do not have to be dealt with at this plant.

The author has given a very clear description of the precipitation and clean-up practice, and has detailed the methods employed for overcoming the difficulties arising from the presence of such large quantities of copper in solutions and precipitate; this part of the paper in particular should be found extremely useful to those treating ores similar to that at the Central Plant of the T.G.M.E., Ltd.

Mr. L. W. Macer *(Associate)*: The following notes upon experiments upon Pilgrims Rest ore, and upon the plant subsequently designed for its treatment may be of interest in connection with Mr. Lindsay's paper.

The analysis of the ore, which may be taken as typical of the oxidised ores of Pilgrims Rest, was as follows:—

	%
Silica and silicates (insoluble in acids)	67·890
Ferric oxide	23·100
Alumina	1·830
Manganese oxide	0·184
Zinc	0·037
Cobalt	trace
Nickel	Nil
Copper	0·066
Lead	0·013
Bismuth	0·024
Arsenic	0·136
Antimony	0·171
Tellurium and selenium	Nil
Sulphur	0·063
Sulphur trioxide	trace
Lime	0·595
Magnesia	0·533
Moisture and organic matter ...	5·380
	100·022

Fine gold: 9·1 dwt. per ton of 2,000 lb.
Fine silver: 1·4 dwt. per ton of 2,000 lb.

Acidity of ore was equal to 10·2 lb. caustic soda per ton of 2,000 lb. used to neutralize.

A large sample (being a representative portion of the remainder of some 1,200 mine development samples) was bucked down to pass 80 mesh. This was quartered down and the resulting sample was bucked down to practically all pass 200 mesh.

The grading was as follows:—

Sands +200	0·42%
Sands –200	48·70%
Slimes –200	50·88%

An amalgamation test upon the above recovered only 36·9% of assay value of the ore. The tailing were treated for four days with 0·185% KCN, and a recovery equal to 5·47 dwt. per ton was obtained, equal to 60·08% of the assay value, and making up a total extraction by amalgamation and cyaniding of 97%, the cyaniding tests being made by shaking.

The average extraction at three small mills in the Pilgrims Rest District, not using any form of secondary grinders, from which the writer was able to secure fairly reliable figures was as follows, based upon screen values and bullion recovered:—

Amalgamation	34·7%
Cyaniding	53·2%
	87·9%

This included gold realised from or estimated as remaining in slags, but must be taken as very approximate owing to the unsystematic nature of the records available. It is nevertheless useful in indicating the low amalgamation extraction obtained from, what appears to be from the analyses, a perfectly unrefractory ore.

From a series of preliminary experiments and observations at various local mills, the writer came to the conclusion that the low extraction was probably due to a combination of conditions, namely, the fine flaky nature of the gold, and the clayey slimes in the pulp, which had the effect of preventing any but the heaviest particles of gold touching the plates. There seemed to be no evidence of gold being attached to the heavier particles of the ore, as a sample of concentrate equal to 0·47% of the sample of tailing after the above-mentioned amalgamation test and before cyaniding assayed 58·7 dwt. only.

The following experiment was then made, which seemed to throw light upon the matter:—

A sample weighing 9,280 gm. of the 90 mesh ore, upon which the analysis was made, was panned with mercury over a small copper plate and tailing caught. On again carefully panning the tailing no visible gold could be found. It was then dried, mixed and quartered and 2,000 gm. panned off for concentrate, of which 204 gm. was obtained. This contained some coarse sand, in addition to much black sand. The latter was observed to be mainly small cubes, or portions of cubes, of limonite. This concentrate was then ground and again panned, when a small "tail" of very fine gold was obtained. In many subsequent pannings made for the purpose of obtaining larger quantities of concentrate, several successive grindings were made, and each time more gold was to be seen. The writer therefore concluded that the gold occurred as films on the cleavage planes of the limonite cubes (oxidized pyrite), and unless the ore was finely ground it did not have an opportunity of touching the plates. On the other hand, if finely ground a dense red slime was formed, upon which the liberated flakes of gold floated over the plates.

The plant was designed accordingly as follows:—Crushing was done by Nissen stamps through 10 mesh screen. The whole pulp was then passed to a 7 ft. slow speed Chilian mill (Lane). The reason for selecting this mill was that it was thought that the slow panning action would automatically select the "black sand" and at the same time grind it to slime, leaving the gold on the die, the slow wash of the water not being sufficiently powerful to disturb it. The pulp was then taken to a cone classifier, the underflow being returned to the Chilian mill, and the overflow was dewatered in a 25 ft. × 10 ft. Door thickener, the underflow of which contained 40% moisture. The pulp (sand and slime mixed) passed to a Hendryx agitator and an air lift agitator, coupled in series, in which the solutions were kept at a maximum strength of 0·025 KCN. The continuous flow from the agitators was desolutionized in three Dorr thickeners in series, the final residue containing as low as 38% moisture, but averaging 42%. The average grading of the pulp gave 62% −90, and average extraction for the last six months' work was 92%, which can be considered satisfactory, seeing that the expense of tube-milling had been avoided. 45·7% of the bullion was recovered by amalgamation during the more normal runs.

The precipitation was attempted by the Merrill process, but was found to be erratic in the presence of copper and with the weak solutions used. The damp atmosphere of Pilgrims Rest may have also had a detrimental effect upon the zinc dust used. It was therefore found desirable to revert to shavings. In connection with the precipitation in the presence of copper, the nature of the shaving seemed to have a considerable influence in its efficacy as a precipitant. A coarsely cut shaving seemed to become almost immediately coated with copper and the tails always tested high. A very finely cut zinc became very brittle, broke up under handling, and soon became inactive.

The above remarks refer to the plant erected at the Blackhills Mine (Transvaal Gold Trust, Ltd.), which may be of interest as being probably the first "continuous" Dorr thickener plant erected in South Africa. It is possible that Mr. Lindsay may find room in his reply to the discussion to refer to the three main points mentioned, namely, selective grinding by Chilian mills as compared with tube-mills, continuous decantation, and precipitation difficulties in the presence of copper, in which case an already most interesting and useful paper would be a work of reference upon the metallurgy of the local ores.

NOTES ON THE SUPPORT OF THE UNDERGROUND WORKINGS OF THE MINES OF THE RAND.

By Percy Cazalet *(Member)*.

SYSTEMATIC PACKING UNDERGROUND AT THE FERREIRA DEEP MINE.

By G. Hildick-Smith, B.Sc. *(President)*, and Paul Selby, B.Sc.

(Printed in Journal, July, 1917.)

DISCUSSION.

Mr. J. D. Marquard *(Member)*: Messrs. Percy Cazalet, G. Hildick-Smith and P. Selby have started a subject brimful of interest, and which should have been taken up ere this. I think the thanks of the Rand mining community are due to them.

Briefly summarised, their papers deal with (1) unsuitability of past work and methods of support; (2) problems of supporting hanging walls throughout the Rand, the methods of which are not uniform; (3) cavings and movements over large and small areas; (4) the failure of pillars; (5) sandfilling; (6) waste packing or filling; (7) props; (8) stulls; (9) pigstyes; and (10) systematic packing of ore actually broken at stope face.

(1) Unsuitability of Past Work and Methods of Support.

The authors have shown that some past methods of support have not been entirely satisfactory. If, then, we continue with these methods we can look for future dangers, increased working costs, abandonment of good grade areas, and, in some cases perhaps, abandonment of whole mines.

The lay-out of most of our deep level mines, where the deepest portions will not exceed, say, 3,500 feet, has in my opinion been rather unfortunate. The two vertical shafts should preferably have been sunk in the centres of the properties, at the northern and southern boundaries, instead of in east and west lines. The northern shaft small and the southern one large.

The advantages of sinking the shafts thus are:—

(1) Only one small inclined shaft, joining up the two verticals, would be necessary per mine.

(2) All drives to the east and west boundaries could be completed about two years after the holing of the inclined shaft.

(3) When that development work is completed, the future history of the whole mine regarding dislocations, grade, etc., would then be laid bare, and definite policies of future finance and methods of exploitation could be decided on.

(4) Financial considerations in regard to getting a mine to the producing stage as soon as possible would not be interfered with to any greater extent than hitherto. The benefits derived, financially and otherwise, after the completion of the development stage, as above mentioned, are almost self-evident.

(5) Breaking of the reef could be started from the east and west boundaries, working homewards. Financial arrangements or considerations may call for earlier stoping; such could be started shortly after the holing of the incline, and discontinued later for home working when the development is completed. Financial arrangements can also be made, so that the preliminary stoping near the incline shafts, while development is proceeding, can pay some of the cost of such development, as well as the cost of some of the surface equipment, and thus prevent the tendency towards over-capitalisation.

(6) All hauling, pumping, etc., could take place *via* the bottom large shaft. The ore could be transported down the incline in a chute or with a mechanical haulage to a well-equipped crusher, above a large-capacity ore bin, at the bottom of the said shaft.

(7) No huge stations, no ore bins and no grizzlies would be necessary off the incline at the various levels.

(8) Air pumps would be unnecessary in various portions of the mine.

(9) The top shaft would need one building at the collar to enclose a good-sized exhaust fan. The said shaft

should be well equipped with strong ladders as a second exit. In Kimberley over 5,000 tons of ore, large numbers of natives and quantities of stores have been transported *via* one deep vertical shaft daily.

(10) The top of the incline would require one hoisting plant for transporting men and material to the various inclined stations.

(11) No bends are necessary.

(12) All surface equipment could be concentrated at the bottom shaft.

(13) Ventilating districts could be better laid out and regulated.

(14) The companies south could, by arrangement, partially utilise the bottom shafts to prove and develop their properties, and in later years could buy those shafts with equipment outright, and thus the top companies may redeem some of the capital originally spent on the said shafts.

It is thus seen how past methods have robbed the present of proper and correct methods of concentration and underground home working, and the extent to which this has interfered with the proper application of safety with regard to the overlying masses. Another mistake was committed in thinking that the hanging walls would arch strongly, and in newly-opened mines stoping was permitted for years without any serious attempts at supporting the so-called strong overlying quartzites. Stretches of hanging were permitted to go unsupported until the limits of elasticity of the overlying slabs of rock masses were reached, and only then attempts at supporting, in a fashion, by means of props and a few pillars were made. We bolstered up what should have been properly supported, and consequently are to-day meeting a serious problem. We are now, however, on the right road towards meeting this problem. Valuable experience had been gained; the best can be taken out of the past to apply to the future, and the Rand may yet have some of the finest supported mines in the world.

(2) PROBLEMS OF SUPPORTING HANGING WALLS, THE METHODS OF WHICH ARE NOT UNIFORM THROUGHOUT THE RAND.

Mr. Cazalet mentions this, but it is only partially true. Whether the reef dips at 30 degrees or 60 degrees, or a mine is 1,000 feet or 4,000 feet deep, the same method of supporting can be adopted with slight variations to meet different conditions. It is granted that, where stope widths are over eight feet, different methods of supporting become necessary.

Further on will be gathered what method is thought suitable for all workings under eight feet stoping width.

(3) CAVINGS AND MOVEMENTS OVER LARGE AND SMALL AREAS.

Experience has shown that the following movements or pressures in the overlying rock burden have to be dealt with:—

(*a*) *Subsiding Pressure.*—This results in large rock masses subsiding, often causing surface cracks.

(*b*) *Major Pressure.*—This is pressure exerted by heavy masses on the move over large areas, often causing earth tremors, shocks or pillar bursts.

(*c*) *Minor Pressure.*—This is pressure which may cause heavy falls of ground, or burst pillars over limited areas, or cause so-called air blasts.

(*d*) *Slab Pressure.*—This results in the falling away of slabs when the limits of elasticity of bending unsupported slabs are reached.

Underground experience shows that the first pressure met with is slab pressure (*d*). This may be local or be the result of either (*c*), (*b*) or (*a*), or all combined, starting to exert themselves. The presence of dykes or faults plays a great part as to how, when and where these pressures or movements come into play. In studying underground conditions much can be learned in regard to them; time, however, does not now permit of going into them at length.

Last month, when the papers were read and discussed, the subject of earth tremors again came to the fore. The report of the Earth Tremors Commission gave the cause most lucidly, and so that the man in the street could fully grasp it. From a technical point of view, I wish to make a few remarks.

Our present reef deposits, with the masses of over and under burden, have been tilted into the present positions by past severe geological actions, and, in addition, these deposits have from time to time been disturbed by numerous intrusions and dislocations. These disturbances or geological revolutions have compressed the rocks, and caused synclines, anticlines and serious ruptures. The original sandstone has been changed into crystalline quartzite by intense compression, and generally there has been much heating, cooling, expansion and contraction. All these, I think, have left enormous pent-up strains in the rock masses, and in some parts of the Rand these strains are more severe than in others.

Our rock masses are therefore in a state of molecular strain. The deeper down the more intense the buried strains, for there has been no chance for such escaping or relieving themselves. These tilted rocks, for ages in a state of strain, had the uppermost strains relieved as denudation advanced and the presence of the overburden lessened; that is one of the reasons why the origin of earth tremors are not commonly traced to the outcrop mines.

Before mining was started the earth crust on the Rand was in a condition of equilibrium. The mining has changed that condition to a critical condition of equilibrium. There is now:—

(*a*) The overlying pressure or weight exerting itself.

(*b*) The pent-up strains seeking relief.

Both these increase in intensity as the underground workings are extended. When the limits to rigidity or elasticity due to pressure, etc., are reached ruptures take place, or when the enormous pent-up strains, under compression, find relief in the mined-out areas, then these give rise to waves of elastic distortion, and the passages of the said waves through the rock masses constitute earth tremors or shocks. These waves are deflected, delayed or arrested depending upon the elasticity, structure or consistency of the material of the rock masses they encounter.

On the Central Rand we have two large dykes running north—firstly, the Robinson Dyke (Syenite), which passes through Turffontein, Booysens, Johannesburg, Braamfontein, Milner Park, Parkview and beyond, and, secondly, the Crown-Ferreira Dyke, the Grahamstown Dyke and the Wemmer Dyke, which run west to east and then turn northwards. North of the outcrop, it seems, they join into one dyke, which courses straight north, passes east of Park Station through Berea and beyond.

The large expanses mined on the Central Rand allow of movement along and against these dykes. The slipping down of only 1-100th of an inch with such enormous masses, under intense strain, is enough to cause serious shocks, and the bursting of resisting mine pillars. The waves of elastic distortion perhaps travel more easily along the dykes, which are better conductors than the surrounding bedded quartzites. It will be interesting, if enquiries could be made after shocks, or if experiments could be conducted, to find out whether such shocks are more severe along or in the neighbourhood of these dykes than elsewhere. To me it certainly seems feasible south of the mines, where the overlying quartzites are disturbed and not as compact as the dykes running south.

Pressure, combined with pillar bursting, is no doubt the greatest contributory cause to earth tremors or shocks on the Central Rand, and there the amount of stoped as against unstoped area is the greater.

At the Cinderella Deep the amount of unstoped area is the greater, and it seems that pressure there is not the greatest contributing cause to earth tremors. We know that, in the long past, geological disturbances have been great in the Boksburg, Benoni and Rietfontein areas. These have probably left severe, deep-seated, pent-up strains in and about the Cinderella Deep reefs and quartzites. I think some of the shocks there are the results of such strains relieving themselves in the stoped-out areas, and that is why the stope faces burst out, the footwalls rise or other serious movements take place. In the Simmer Deep, again, with deeper and more extensive workings, pressure is the probable cause of tremors.

To say that the giving-way of a pillar under pressure is the cause of an earth tremor is right from one point of view. It is also right to say that the same sudden movement which caused the pillar to give way caused the earth tremor, yet had the pillar not been there no sudden movement would probably have occurred. You may stand on a lump of sugar with your heel; after a little time that lump suddenly collapses, and you go down feeling a shock through your whole system; but if you stood on a strong resisting wire spring you will go down with practically no shock to your system at all. This illustration can be applied to the mines. The inference is, do away with non-compressible pillars which suddenly give when the overhead pressure gets too great, put in compressible supports in the stoped-out areas, thus changing the critical condition of equilibrium of the overhead masses into a gradual arrestable condition of equilibrium, and minimise earth tremors which are only the results of mining operations and need never cause anxiety.

(4) THE FAILURE OF PILLARS.

In 1903 I started shift-bossing on the Rose Deep, Ltd. Three things with regard to the hanging walls on that mine impressed me very much during that year. These were:—

(1) In an old stope, worked before the war, a forest of prop timbers was seen; the timbers were bent and cracked across the middle, and were supporting hanging wall. The question arose—if there was force or weight enough to bend or break these sticks when they exerted the greatest resistance in upright positions, then why did that weight not bring in the stope, seeing that the sticks have practically no more resisting force?

(2) Towards the end of 1903 a pigstye of round 7-inch sticks, 6 feet long, was built to support a ledge of hanging 54 inches thick above a 72-inch stope. The mine overseer told me that this was a waste of timber, and that I should support the rest of the stope with props. This I did, with a liberal number. Four years after, I left the Rose Deep, but not before I had the opportunity of seeing the stope practically caved, with the pigstye alone standing somewhat compressed with a slab 14 feet by 12 feet by 54 inches on top of it, and on that slab was fair overhead pressure.

(3) A number of fairly well-pillared stopes were in a dangerous condition, hanging was eaving between the pillars, while the pillars themselves were practically intact.

These three points formed my A.B.C. education with regard to Rand hanging. It was there I learned that what the mines needed was a compressible form of support, and that solid rock pillars was wrong practice.

It appears necessary to have supports which will take up slab and minor pressures in turn and later on reduce the effects of major and subsiding pressures. That is supports which will gradually take up the pressure and permit of it gradually spending itself in compressing these supports, or in other words the supports must be compressible so as to take up the inherent overhead forces or strains and distribute them as much as possible within the said supports, and thus gradually arrest movements and minimise falls.

Even to-day one hears, especially from some colliery men, arguments in favour of solid pillars as opposed to compressible supports. It must be remembered that they have had their experience in comparatively shallow mines, and that their pillars, consisting of coal, are thus quite compressible compared to ours which are of solid rock. Of course the deep European collieries leave no pillars at all.

(5) SANDFILLING.

Much has been said before the various Societies about this method of support. Its adoption can certainly be recommended for wider extension than hitherto attempted. It is true that sandfilling is not a rigid support, but that is an advantage. If we wish in future to safeguard many of our vertical shafts from movement, it seems it may be necessary to remove all solid shaft pillars and to replace them by sand, the sand in the worked-out areas behind the shaft to continue fairly far to the north of the shaft. The movements in the extensive worked out areas around the present comparatively small and solid shaft pillars may in future seriously affect these shafts, but sand in place of these pillars and for areas far exceeding that of the present pillars will not permit of serious shaft disturbances; the compressibility of the sand will be the main factor in this.

As a mine steadier sandfilled areas are difficult to beat. The Simmer and Jack, in years past, gave the Mines Department some worry on account of the number of falls of rock they had. That mine was then on the move. Thanks to the foresight of the manager, he caused certain areas to be sandfilled, and as block after block of sand came into being less and less became the falls in other parts of the mine, and gradually the mine became steadied. If they had not done that they might have lost large portions of the mine. Now all their current sands are being sent down the mine. I think any mines on the move can be steadied by blocks of sand, and it is worth a trial. Blocks of sand throughout a mine will also have the effect of minimising earth tremors. I would even go so far as to say that mines which have stopes over eight feet in width—and some have them 30 feet in width—should adopt sandfilling; if they do not the future may see portions of these mines mere holes in the ground. Our mines have not as yet tried to solve the problem of sandfilling contemporaneously with stoping. It can be done and it is done in coal mining in Silesia where the average profit per ton of coal is less than the average profit per ton of Rand ore. Sandfilling is being successfully applied to supporting our railways over mined areas. As a means of isolating portions of mines so as to regulate ventilating districts it should also be useful.

(6) WASTE PACKING OR WASTE ROCK FILLING.

Waste rock, unless it rests against very strong barriers, is not an effective support for stopes dipping over 33 degrees. Below that it is quite effective. It complies with the compressibility spoken of above. I like it as a support under railways where the width of the excavation to be packed is not more than 54 inches. These packs should be parallel, should stretch from drive to drive, and should not be less than 20 feet wide and not more than 20 feet apart for the whole area of railway reserve. In mined areas under the railway reserve, where the stope width is over 54 inches for all dips, or under 54 inches for dips above 33 degrees, I think sandfilling is the best support to adopt.

In many mines some forms of systematically placing waste packs fair distances apart are adopted. These, in places, seem to answer to good purpose, but I would suggest that such packs be built round, for the corners of square packs are weak points.

In some mines the widths of the reefs vary from 2 inches to 72 inches in thickness. The 2-inch reefs are carried in 36-inch to 42-inch stopes. Why could these not be first carried for 36 inches in waste only, and then the reef picked up in 12 inches of waste from the footwall, these operations to be carried on alternately every 10 feet of face advance? The waste stoped in the 36 inches can then be firmly packed in the 48 inches, and what is over utilised to advantage elsewhere. If a calculation for such a stope be gone into and the following points only taken into account, namely: (1) no timber or timbermen needed for stopes; (2) no cutting of pillars necessary; (3) less labour needed; (4) one-third the tonnage to shovel, tram, haul, sort, treat and dump for the same amount of gold got; (5) the steadying effect of these blocks of waste filling on the mine; and (6) serious accidents from falls practically *nil* in stopes and very few in drives in those neighbourhoods;—the extra cost at the stope face is then easily balanced, and ultimately more profit from such a stope will result.

(7) TIMBER PROPS.

Props as supports are largely used underground, and in outcrop mines are most beneficial, especially in free milling ground where their use with head boards or cap pieces are certainly most effective. I think their use in deep mining, except for temporary measures, should be abandoned. In some of our shallower mines their use can be more beneficial, from a safety point of view, if the European practice of systematically placing them is adopted, and, where excessive weight commences to show, series of four of them can be utilised as bases for pigstyes or waste rock filled in between lagging poles placed within and against four such props.

(8) STULLS.

Stulls, if properly put in and well loaded, are good for arresting heavy falls of hanging from careering down steep stopes. The majority of stulls I have seen in these mines are certainly not supports for the hanging walls; they are badly and weakly constructed and simply serve for hanging to break off against them. It is true if a stull is strongly built and well filled up with waste or ore on top, that it acts as a fair support; it would be even a better support if the stull had wings to it, so that the filling on top could be carried a good distance up above the stull. If strong supporting stull timbers are not well hitched between the hanging and footwalls, nor strongly lagged nor well filled behind, or if the filling has to be removed at week-ends for mill bins, then stulls should be considered negligible factors in supporting hanging walls in stopes. An unloaded stull may be erected for safety, but in my opinion it is a troublesome thing and gives a false idea of security. It might arrest small falls of rock day by day and save slight injuries, but one day a large fall crashes through it and perhaps accounts for the lives of half a dozen natives below.

(9) PIGSTYES.

In some previous remarks it was stated that one method of support, regardless of dip and depth, is suitable for all stopes under 8ft. wide. That method is the pigstye method, which can be made adaptable or variable to meet practically all contingencies.

Advantages of Pigstye Support.

(*a*) For the cost of cutting an 18ft. x 18ft. pillar with machines, in a 5ft. stope say, one can put in eight 6ft. x 6ft. pigstyes. These pigstyes will support a greater area than the pillar, and an ultimate greater profit from that portion of such stope can be looked for.

(*b*) Pigstyes will take slab and minor pressure so as not to allow the hanging to crumple, but to come down slowly in large slabs or masses, thus limiting falls and accidents.

(*c*) Major pressure and subsiding pressure can be kept under control.

(*d*) Stopes can be kept open long enough to finish all necessary work therein.

(*e*) Earth tremors or shocks will lessen or be less severe as the heavier pressures are gradually being controlled, and so-called air blasts will be brought down to a minimum.

(*f*) Punching of hangings and footwalls, such as occurs when pillars are used and the consequent dangerous breaking up of all three will be things of the past.

(*g*) Pisgtyes can be brought to within ten feet of the face if proper precautions are taken against blasting.

(*h*) The gradual compression of the pigstyes will either permit of such pressure on stope faces that the ground will break fairly easily, or of liberal use of pinch bars on these faces.

(*i*) Strains or overhead forces will relieve themselves in compressing pigstyes instead of by breaking up the hanging walls.

(*j*) Increased efficiency can be looked for in many other branches of mining work.

On the Rand we have not given enough study to the character of the timber we are using. It would pay the mines if the Chamber of Mines, together with the Government Forestry Department, could look into the matter, especially as to the best kinds of timber to cultivate and use.

Our timber decays faster in our mines than in some of the European mines, because (*a*) no proper attention is given as to the time of the year we fell our trees; (*b*) almost daily green timber goes underground, and fermentation of the sap is a serious cause of decay; (*c*) the timber is not stored under cover, or so that the air could pass around it and allow of proper seasoning; and (*d*) no attempts are made to preserve the timber, so as to prevent dry or fungus rot attacking it too soon.

In France and other countries the bark is removed, the cleaned timber is properly seasoned, and then soaked in some preserving solution at an average cost of half a franc per 8ft. pole of 8in. diameter. In Belgium in some mines the cleaned seasoned poles are coated with carbolineum at ¾d. per running foot for a 10in. diameter stick. Both these methods cause timber to last five times as long. If our timber even lasted only three times as long with these preserving methods it would pay us handsomely.

To return to pigstying again, I might say that I think the time has now arrived for the Witwatersrand mines to adopt a systematic practice of supporting the hanging walls with pigstyes. We must give up the wrong past methods of putting a support where so-and-so thinks one necessary and then places one there almost regardless of thought of the future. Accident enquiries have shown that the past methods are sorely in need of betterment.

What the Rand wants is a fair number of strong compressible supports, placed systematically near to each other instead of very substantial ones placed systematically far from each other. We know that nothing will keep up our rock masses indefinitely; we only want the workings to be kept open so long as we need them, and it will then be found that in the long run the small strong supports placed systematically near to each other will be more effective than large ones placed far apart.

I am a believer in pigstyes built of 6ft. sticks of square section 4in. x 4in., especially in the steep stopes, or 8ft. sticks of round section 5in. diameter in the flatter stopes.

Filling of pigstyes with waste rock is essential in the flatter stopes. If the small 6ft. x 6ft. pigstyes of square section preserved timber are adopted, I would suggest that in steep stopes they be not filled with waste rock, for then the air cannot get around the timbers and they may decay fairly quickly.

In steep stopes these light pigstyes are easily constructed and temporarily supported until the oncoming weight binds them. It must be remembered that steep stope faces are generally advanced by hammer boys; the advance is slow, and the rows of pigstyes can easily be kept up to date.

If these small pigstyes are placed their own width apart, that is 6ft., one will be required for every three fathoms stoped, and that is certainly not too costly. In steep stopes laggings can be crossed over from pigstye to pigstye for overhead safety from falling rocks and materials.

I saw a return of timber which was supplied in a steep mine on the West Rand during a year. I also saw what fathomage, with the average stope width, was stoped for that year. If the cubic footage of timber so supplied for that year had been changed into pigstye supporting as above described there would have been more than sufficient timber to put in one pigstye for every three fathoms stoped, and the workings would have been better supported.

I think the above systems quite sufficient to keep our drives well open without drive pillars. It is often required that a certain drive must be kept open for many years. In that case I would suggest that the spaces between the three rows of pigstyes immediately above and below those drives be completely filled with waste rock or sand resting on substantial barriers against the pigstyes or additional supports if necessary. In some worked-out portions of mines it may be found practicable and economical to remove some of the preserved timber pigstyes and reconstruct them elsewhere.

We still have in vogue to-day large stoped out areas along the strikes as well as the dips of the reefs, and these areas are inferiorly supported, the result being that a live pressure is always being kept up. The further stoping extends the livelier the pressure becomes. This live pressure makes things extremely unsafe; nothing else can be expected if everything is on the slow move. This live pressure or slow move must be changed into a dormant or resting pressure, and the best way I can at present conceive of doing it is, as above described, by pigstyes, etc. The pigstyes must be commenced soon after the faces have started off a winze. It is, practically speaking, too late to start if sagging or pressure has had too much of a chance for exerting itself. The pigstyes must be in position before, so that the first weight or sagging will be taken up by the compressing of some pigstyes and thus be subjected to a gradual checking. Strains being thus partly checked will partly radiate or distribute in the hanging from the main sagging centre and attempt to disturb or dislodge hanging further on, but in this event there is the stope face or other pigstyes in between which will prevent these consequences. Thus when the stope extends and the pigstye placing is kept up to date the hanging will gradually come on to the pigstyes, compressing them, the live pressure being brought to a dormant or equally distributable state. My experience is that in the dormant state all pressure is easy to deal with, no serious isolated falls take place, hangings do not suddenly crack up, and movement is gradual over large areas. It may be said that with heavy weight the small pigstyes crumple away; this is true, but only if there are not enough of them. As stated before, my contention is that the Rand requires numerous fairly substantial compressible supports systematically placed in preference to few very substantial compressible ones so placed. I may be wrong; the future will show if my contention is correct or not.

In the Consolidated Main Reef and Main Reef West Mines a system of pigstying has been adopted which, I think, is every bit as good as the suggested system and most suitable for the flatter mines. I would advise those interested in pigstying to go and see their methods and before coming away remember that it is being done in a low grade mine. Their method of protection against blasting is also ideal. I understand that there are several other mines where the same system is in vogue, but I mention these two mines as I am more intimately acquainted with them than the others.

A point somewhat neglected in the past is the study of how, when and where to mine various overlying reefs. Grade is often the first consideration instead of safety, and a reef is worked above or below another stope with sometimes little thought for the future. It may even be found necessary in some places to remove pigstyes, etc., from the top stopes so as to reduce transmitted pressures from the overlying masses above the top stopes to the lower stopes.

(10) SYSTEMATIC PACKING OF ORE ACTUALLY BROKEN AT STOPE FACES.

It must be remembered that the Ferreira Deep, like some others, is a mine in which perhaps serious mistakes may have been made in the past. It is a rich mine, and can afford to do things which a poorer mine cannot. I do not condemn the method of systematic packing of ore actually broken at the face; far from it; I think it is a good method, but at the same time I think proper pigstying a better one. The Ferreira Deep was allowed to get on the move and some drastic method had to be adopted or else large portions of that mine would have developed serious difficulties. Thanks to that drastic method, however, the result has been to bring to the fore a good method of supporting hanging walls.

I am of opinion that had pigstying been started on the Ferreira Deep in the long past and continued, the method now adopted would probably not have been in use.

This method now allows of a good system of supporting hanging walls with good ore and reclaiming of the good ore, and withdrawing that good system of support later and replacing it with inferior temporary supports during such reclamation. The leaving of the hanging wall after reclamation with few supports in a critical condition of equilibrium may, however, result in earth tremors, and the keeping open of certain necessary drives will be difficult and costly.

In the papers under discussion certain advantages for the system were claimed. Certainly all those advantages exist, and many more, but I think they can likewise be claimed for the pigstye system. It must be admitted that the best for the Ferreira Deep now is the continuation of their system of support. It is not advisable for a mine which has developed a good system to start on another.

It is also well to remember if many mines adopt the systematic packing of ore actually broken at stope faces, that a large amount of money in the shape of broken ore will be lying about which, I think, should be drawing good interest. The ensurance of safety is, however, the first consideration, and if this is being attained then the interest on the money is of secondary importance.

The foregoing remarks are not for the purpose of criticism. No one can really afford to criticise, for all are learning, and the remarks are meant as additions to the two valuable papers. I have had a fair experience of how the hanging walls are supported in the Germiston district. Time will not permit of some interesting remarks in regard to that district. I feel sure, however, that a number of the well-known Germiston mining engineers will contribute some valuable additions. In that district one often sees three stopes, one above the other, mined separately within a total thickness of 33 feet of rock, and if there are men who can tell us about difficulties with regard to hanging wall support they are the Germiston mining men, for in addition to the various pressures mentioned they have also to deal with the keeping up of waste partings.

Review.

HANDBOOK OF MINERALS.

By G. Montague Butter.

Published by John Wiley & Son, New York, and Messrs. Chapman & Hall, 11, Henrietta Street, Covent Garden. 6 in. by 4 in. Price 11/6 net.

A veritable pocket "Dana"! A book that will receive a welcome by every student of mineralogy. As far as we have been able to judge, it is free from misprints and inaccuracies, no small thing in these days. The book is compiled as purely and simply a field reference, dealing with the lustre, colour, streak, cleavage, tenacity and fracture, translucency, specific gravity and miscellaneous characteristics of most of the well identified minerals. One estimable feature is the reference to minerals which have common characteristics to one another. Included in all this are brief references to the uses of the mineral: a glossary of terms: a list of commercially important ores: and a list of retail prices of cut gems, with pre-war prices of trade minerals. The little book is completed by a series of tables dealing with the ordinary characteristics enabling the student to make comparisons. One essential feature is the allotted blank spaces for notes. If there is any fault to find with the book it is a publisher's one, in using paper of different quality in the paging, but this may be due to war conditions. We have pleasure in recommending this publication to field geologists, mineralogists and all students in these subjects. Features we have omitted, hitherto, to mention are the adoption of Dana's number against each mineral described, and the number of beautiful photographic reproductions of minerals. The former will enable any one to compare little known varieties with Dana's System of Mineralogy.

The book could well be fitted with a water-proof case for the convenience of prospectors. (A. W.)

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Salt Manufacture by Solar Evaporation of Sea Water.—"The process is carried out at San Diego Bay in Southern California, a long and narrow land-locked arm of the Pacific Ocean. The sea water is admitted each fortnight at high tide from the bay to four tide ponds, from which it is transferred by pumps for another two weeks to upper secondary ponds, and then to lower secondary ponds. The calcium carbonate settles out in these ponds, and the liquor is then transferred to the 'pickling pond,' where calcium sulphate is precipitated. The brine is finally drained to the crystallising pond where the salt is separated, and from this pond the liquor is passed to the bittern ponds. The salt is shovelled into cars, delivering into a bin from which the salt is discharged by a screw conveyor and an elevator into the washer, where it is treated with brine from the pickling pond. It receives a further brine washing and is sprayed with fresh water whilst being elevated to the stack piles, where it is dried."—L. A. Palmer, *Met. and Chem. Eng.*, 1917, *16*, 317-319. *Journal of the Society of Chemical Industry*, May 15, 1917, p. 502. (J. A. W.)

Utilisation of Nitre Cake.—"A method is suggested for the utilisation of nitre cake which avoids serious loss of either sulphur or alkali and also the difficulties of transit or storage of the nitre cake itself. If nitre cake is heated with sand, sulphuric acid is evolved and a soda frit is obtained which, however, still contains some sulphate. Increase of the proportion of sand reduces the amount of residual sulphate, and this is reduced still further by the use of charcoal, sulphur and sulphur dioxide being then formed along with the sulphuric acid. The soda frit may be converted into a glass by melting with suitable oxides, etc. If the use of fluorides is avoided, the recovery of the sulphur and the formation of a glass may be carried out at one operation, the retort being connected with a sulphuric acid plant. In one experiment a mixture of nitre cake (65 gm.), sand (100 gm.), limestone (18 gm.), and wood charcoal (6 gm.) gave 120 gm. of soda-lime glass, 2·37 gm. of sulphur, and 23·1 gm. of 80% sulphuric acid, the total percentage of sulphur recovered being 52·8. By increasing the quantity of charcoal in this mixture up to 8 gm., the sulphur recovery rose to 66% to 70%; higher amounts of charcoal led to the production of black glasses. In these experiments a nitre cake was used containing 68·8% of sodium bisulphate. For further experiments on the production of a lead glass, the nitre cake contained 80% of bisulphate, red lead with a little nitre and borax replacing the limestone and charcoal. Coloured glasses were obtained by the addition of the usual oxides. The efficiency of sulphur recovery was about 66%, as in the case of soda lime glass, all as sulphuric acid, the oxidising action of the red lead and nitre preventing the separation of sulphur. The time of heating varied in the case of the soda lime glass from 9 hours up to 18 hours, most of the sulphur being evolved in the first two hours; in the case of the lead glass the time varied from four hours to seven hours."—G. T. Morgan, Econ. Proc. Roy. Dublin Soc., 1917, 2, 238-247.—*Journal of the Society of Chemical Industry*, May 15, 1917, p. 504. (J. A. W.)

Analysis of Aluminium Dust.—"One gram is dried at 100° C. to constant weight and the loss reported as moisture. The dried material is transferred to a dry 200 cc. beaker and washed with ether till free from grease. The filtered extract is evaporated in a tared flask and the grease weighed. The residue from the extraction is transferred to a 300 cc. flask and dissolved in dilute hydrochloric acid; the hot acid solution is filtered through the filter previously used into another flask, and the filter washed with hot water. The insoluble residue is washed back and treated with nitric acid; this solution is filtered through the same filter into a separate flask. The ignited insoluble residue consists of silica mixed with some carbon which resists ignition very persistently. It is fused with a small quantity of sodium peroxide and the silica separated as usual; this is calculated to silicon. The nitric acid filtrate is evaporated with sulphuric acid and added to the main hydrochloric acid filtrate. This is precipitated with hydrogen sulphide, and the precipitate digested with hot 50% hydrochloric acid to separate copper and lead. The residual copper sulphide is dissolved in nitric acid and the copper titrated with cyanide. The lead solution is neutralised with ammonia, acidified with acetic acid, and precipitated with bichromate. The filtrate from the hydrogen sulphide precipitate is oxidised and treated with excess of caustic soda; the precipitate is dissolved and re-precipitated with ammonia; the filtrate from the ferric hydroxide is used for the estimation of magnesium. The alkaline filtrate containing aluminium and zinc is precipitated with sodium sulphide, and the zinc sulphide determined with $N/10$ iodine and thiosulphate. The aluminium may be roughly determined by acidifying the last filtrate, expelling hydrogen sulphide by boiling, making up to 500 cc., and titrating 100 cc. with $N/1$ alkali first with methyl orange, and then with phenolphthalein as indicator. The interval between the two end-points is proportional to the aluminium; the alkali is standardised against pure aluminium. Special methods for the separate determination of the impurities are also described."—J. E. Clennell, *Eng. and Min. J.*, 1917, *103*, 496-499.—*Journal of the Society of Chemical Industry*, May 15, 1917, p. 506. (J. A. W.)

Determination of Sodium and Calcium Bicarbonates in Boiler-Feed.—"The case of a boiler water is considered which contains only bicarbonate alkalinity and is therefore neutral to phenolphthalein. The determination consists of two titrations with $N/10$ acid in presence of methyl orange, firstly directly on the water, secondly after addition of $N/10$ caustic soda equal to the acid used and removal of the precipitate by filtration. The acid used in the first titration is subtracted from that used in the second, and the result multiplied by 8·4, gives the amount of sodium bicarbonate in mgm. per 100 cc., if 100 cc. of the water was taken. The acid used in the second titration is subtracted from twice that used in the first, and the result multiplied by 2·8 gives the amount of lime in the form of bicarbonate. Should there be a trace of phenolphthalein alkalinity in the water, this is titrated with the acid, and twice the result is subtracted from the second titration before calculating the sodium bicarbonate content. Calcium sulphate can only be present in the absence of sodium bicarbonate, and in this case twice the phenolphthalein alkalinity must be subtracted from the first titration before calculating the lime content. Salts of magnesium cause no irregularities in the method."—M. Monhaupt, *Chem.-Zeit.*, 1916, *40*, 1041-1043.—*Journal of the Society of Chemical Industry*, February 15, 1917, p. 160. (A. W.)

Analysis of Babbitt Metal.—"*Antimony.* 1 gm. of the sample (filings) is heated with 10 cc. of water and 25 cc. of sulphuric acid until no black particles remain. The cooled solution is then diluted with 100 cc. of water and 10 cc. of hydrochloric acid, boiled for 10 minutes to expel sulphurous fumes, and titrated with potassium permanganate after being cooled and further diluted with 100 cc. of water. *Tin.* 0·5 gm. is dissolved in hydrochloric acid (with potassium chlorate if necessary) and the tin determined by titration with $N/10$ iodine solution after reduction with soft iron and hydrochloric acid. *Lead.* Solution is effected by dilute nitric acid in the presence of a large excess of tartaric acid. Sulphuric acid is then added and the solution boiled sufficiently to expel all nitrous fumes but without charring the tartaric acid; after which the lead sulphate is filtered off, dissolved in ammonium acetate solution, and the lead reprecipitated and weighed as chromate. *Copper.* Solution is effected as in the preceding case and the filtrate from the lead sulphate is further acidified with hydrochloric acid and heated with pure aluminium. The precipitated copper is filtered off and redissolved in dilute nitric acid for determination by the electrolytic or iodide method."—E. W. Hagmaier, *Met. and Chem. Eng.*, 1917, *16*, 84-85.—*Journal of the Society of Chemical Industry*, February 28, 1917, p. 221. (A. W.)

Determination of Nickel in Presence of Zinc and Iron.—"The estimation of nickel by electrodeposition from an ammoniacal solution cannot be carried out accurately in presence of zinc or manganese, nor with a sodium sulphite solution, when cobalt is present. It was found that precipitation of nickel sesquioxide by alkali and bromine water does not serve entirely to exclude zinc. A separation can be brought about by dimethylglyoxime, but nickel precipitated in this is contaminated by iron if this is present in the solution. This contamination by iron occurs even in presence of a large excess of citric acid and was found to be due to adsorption. To overcome these objections in the estimation of nickel, it is recommended to precipitate with dimethylglyoxime, dissolve the precipitate in nitric acid, heat for several minutes together with hydrogen peroxide, add a large excess of ammonia, and electrolyse in the usual manner." S. Rothschild, *Chem.-Zeit.*, 1917, *41*, 29-30.—*Journal of the Society of Chemical Industry*, February 28, 1917, p. 238. (J. A. W.)

METALLURGY.

New Method of Precipitating Gold from Cyanide Solutions by Zinc.—"A revolving cylinder, 10½ × 16 ft., inclined at 30°, with an inner cast-zinc lining and a central spiral rib acting on the principle of an Archimedean screw, is used. The inner space is filled with zinc balls and small zinc fragments. As the cylinder revolves, the zinc balls travel upwards, and at the end of the spiral they drop into a small central pipe and travel again to the bottom of the machine. The cyanide solution, flowing through the tube, and the rolling of the zinc, remove the precipitate from the surface of the metal. The solution takes place in a steep conical zinc-lined vat. Iron cannot be used, as zinc in contact with iron does not precipitate silver from cyanide solutions. The advantages of the device are that zinc is used in its cheapest form; no excess of zinc is used; clean precipitate is produced which can be melted with fluxes without intermediate acid-treatment or roasting."—H. R. Conklin, *Eng. and Min. J.*, 1917, *103*, 195-196.—*Journal of the Society of Chemical Industry*, March 15, 1917, p. 292. (J. A. W.)

Wet Assay of Tin Concentrate.—"Very serious errors may be introduced in crushing the sample, agate being the only material unaffected by cassiterite. A sample crushed in different mortars was assayed for tin with the following results: unpowdered, 75·1; in agate, 75·1; in steel, 74·0; in Wedgwood mortars (3 different types) 73·35, 73·65, and 72·95%. The colour of the powdered material from the steel mortar was much darker than that crushed in agate. For reducing the solution prior to iodine titration, it is recommended to add 5 gm. of pure powdered zinc after nearly neutralising the excess of acid; 50 cc. of hydrochloric acid is then added, a nickel coil is inserted, and the solution boiled for 10 minutes. The solution is cooled in an atmosphere of carbon dioxide and titrated. Ores containing tungsten, arsenic, or copper should be treated with acid before fusion. Titanium was not found to interfere when the ore was decomposed with lime and zinc-nickel used for reduction."—H. W. Hutchin, *Bull.* 149, *Inst. Min. and Met.*, 27 pages.—*Journal of the Society of Chemical Industry*, March 15, 1917, p. 293. (J. A. W.)

Tube Mill Practice.—*Synopsis—Comparing the performance of three different tube mills under varying conditions and with various linings and pebble charges, gives some interesting information. The classification efficiency was formulated. Close-grained felsite served well instead of the usual Danish pebbles.*

"Thanks to the opportunity for testing three tube mills at the Lonely Reef Mill, Rhodesia, South Africa, with different linings and under varying conditions, it was possible to make definite comparisons of output and efficiency. Early in 1912 the plant was operating on a system that allowed for the handling of coarse-mesh battery product in cones of the baffle (Caldecott) type and with no further attempt at classification. Each mill was provided with one cone which received a proportionate amount of battery pulp and delivered the underflow to the tube mill and the overflow to the Dorr thickeners.

The original design was based on a misunderstanding as to the efficiency of such a cone, working 'dry,' to act as a classifier. By estimating the actual undersize and oversize tonnages of underflow and overflow, after adjustment of the cone to produce a minimum of oversize in the overflow and a minimum of undersize in the underflow, the results obtained were poor. Such units often prove useful as dewaterers, but cannot be considered in the same class as vertical-sided classifiers of the mechanical type, such as the Dorr.

In calculating the efficiency of classification a system was formulated for the purpose of a comparative statement of results and was used in the case where a division of 200-mesh material was required. In this system, the total ore tonnage to classifier per 24 hours $= A$; the tonnage of -200-mesh material in cone overflow per 24 hours $= a'$ and the tonnage of $+200$-mesh material in cone overflow per 24 hours $= a''$. Then

$$\frac{100(a'+a'')}{A} = \textit{efficiency of classification}$$

Experience has shown that the only satisfactory method of obtaining classification results from these cones is to use them in series. W. R. Dowling explains that 'in all cone as well as in other methods of hydraulic classification it is important to have sufficient return-sand cones, operated with fluid underflow, to receive the overflow of the primary cones, so that the contained sand may be separated and returned to the primary cones. The more complete the separation of slime in the primary cones, the more sand will be contained in the overflow, and hence the greater necessity for efficient return-sand cones.'

The inefficiency of the work of these cones at the Lonely Reef mill led to the installation of an additional cone, running 'wet,' which took the overflow from the 'dry' baffle cones, and catered for a large tonnage of coarse material, which inevitably formed a part of the primary-cone overflow.

The usual method of erecting tube mills in South Africa is to place them at a considerable height from the ground. This makes the elevation of battery pulp a necessity. Centrifugal pumps are largely used for this purpose, but often give an erratic discharge, especially when the liners and runners are worn. Various methods of dealing with this trouble are taken advantage of, such as the use of equalising vats, bypass systems, etc., but classification under these conditions is seldom so satisfactory as when the machine receives a steady feed direct from the battery.

After the secondary cone was installed at the Lonely Reef mill, the underflow was returned to the sump of a centrifugal pump which elevated the battery pulp to a distributor supplying the tube mill cones. The overflow from the secondary cone went directly to the Dorr thickeners.

The underflow discharge from the baffle cones was delivered into the tube-mill feed-boxes, where the material was picked up by the usual type of scoop feeder. Solution was added to reduce the specific gravity of the pulp, but it was found permissible to lower the moisture content below the usual percentage, the increase in power consumption being more than compensated for by the increase in tonnage ground.

The tube mills were all fitted with bell ends, an arrangement for which I have never been able to discern a single advantage. The original end-liner design was faulty, and a space was left into which gravel and small pebbles often found their way. Scouring of the mill-end then occurred, and breakage of the trunnions was a comparatively common occurrence. End liners were then designed of a thickness varying with the severity of wear, being about three times as thick at the junction of trunnion liner and end liner as at the internal periphery of the mill.

Tests on Types of Liners. The mills were origi originally designed for silex liners, set in magnesite. These proved hopeless. In addition to the need for constant repair, due to the collapse of one or more liner blocks, there was a material loss in duty as a result of the reduction in the effective diameter of the mill. The smoothness of the interior also detracted from grinding efficiency.

A number of full-scale tests were then carried out and comparisons made with various designs of metal lining. A Komata lining was installed in one of the mills and the speed reduced to satisfy the requirements of this particular type. It was found, however, that the reduction in speed resulted in a serious diminution in duty. Further investigations showed that the grade of product being handled (about 6 holes per square inch) was too coarse to be effectively slimed in a mill of this type at the reduced speed. By returning to a speed based on Davison's formula ($s = \frac{200}{d}$, where $d =$ diameter in inches, and $s =$ the r.p.m.) the Komata still showed a lower efficiency than other types.

At the same time a second mill was equipped with ordinary El Oro lining, and comparative tests were made between this and the Komata lining. The results were conclusive and led to the adoption of El Oro in both mills.

Further tests were made on a third mill with a type of lining known locally as the Osborne, in which steel strips a few inches wide, an inch or so thick, and the length of the mill, were placed alternately flat and edgewise around the inside of the mill. These were kept in position by a wedging action without bolts. The results, however, were not satisfactory, and the third mill was then equipped with El Oro liners. The latter are now made on the property from a special mixture, and are giving comparatively long life at a moderate cost.

As previously indicated, tube milling practice on this property was designed along Rand lines. The original intention was, therefore, to use mine rock in place of pebbles as a regrinding medium in the tube mills. On the Rand a specially hard chert is generally available for this purpose, but the Lonely Reef ore was a friable quartz. Nothing more satisfactory was found in the mine, and it was only after considerable expense that any quantity of tube mill pebbles could be obtained from this material. These fractured in quantity on being fed into the mill, and the production of large tonnages of chips and gravel resulted in very low output and grinding efficiency.

Mine rock of this description may serve in cases where the tube mill merely acts as a regrinder to produce a slightly finer product than is being sent out by the battery, but experience shows that pebbles of good quality are needed to slime efficiently a coarse-ore pulp.

Steps were then taken to find a suitable substitute for the mine rock, and a deposit of close-grained felsite, situated a few miles from the mine, was selected to produce the necessary material. Following along lines instituted in Mexico early in 1910, the rounded pebbles were hand-made under contract, with native labour, the average cost being about $5 per ton delivered at the mine. A double-ring gauge was used to test the stones and to see that those delivered satisfied the contract requirements. This precaution insured that the maximum-sized pebble was fed to the mill without danger of choking the scoop feeder or trunnion intake.

In designing tube mills it is important to allow ample capacity in the scoop and trunnion diameters In the case under review it became advisable to use a very coarse screen on the battery, and this required correspondingly heavy pebbles in the tube mill. It often occurs that the size of the pebble used is limited below the effective diameter on account of the smallness of the mill-feed entrance.

In order to test the work of the mills from every standpoint, a quantity of Danish flint pebbles was imported. The result was a diminution in output and a considerable rise in the cost of grinding. The hand-made felsite pebbles gave by far the best results, largely because of their uniformity in size and weight and the fact that they possessed a granular composition that resisted fracture."—A. W. ALLEN.—*Eng. and Min. Journal*, March 17, 1917, p. 452. (H. A. W.)

THE SMELTING OF TITANIFEROUS ORES OF IRON.—"Although rich haematites are comparatively scarce in Canada, there are extensive deposits of titaniferous magnetic ores, of which the following is a typical analysis: Fe 49·91% (calculated as Fe_3O_4 69·02%), Ti 6·5% (calculated as TiO_2 10·81%), Al_2O_3 4·01%, CaO 5·53%, SiO_2 1·81%. These ores can be smelted without special difficulty provided that SiO_2 as well as $CaCO_3$ is used as a flux. It is, however, practicable to make only a white or low Si iron from an ore containing more than about 1% Ti. It is general practice to enrich by magnetic separation, but this removes only a part of the Ti. The calculation of the amounts of fluxes required is facilitated by the use of a chart which has been constructed showing the m. p. of the slags. Smelting of these ores in competition with richer imported haematites is not practicable because of the comparatively low Fe content, the large amount of flux required and the limitation to the production of low-Si pig. As the S and P in the ores are frequently very low, they may be used to advantage either as an addition to an ordinary furnace charge with the object of improving the quality of the Fe or for whole charges of charcoal blast furnaces or electric furnaces for the production of special qualities of charcoal Fe commanding a high price. A bibliography is appended.—A. STANSFIELD and W. A. WISSLER, *Trans. Roy. Soc. Canada, 10*, No. 111, 33-42 (1916).—*Chemical Abstracts*, April 20, 1917, p. 932. (J. G.)

MINING.

STOPE MEASUREMENT AT THE MESSINA MINE.—"At the meeting of the Institution of Mining and Metallurgy held on April 19, a paper by William Whyte was presented describing the method of measuring stopes at the Messina copper mine, in the northern Transvaal. The orebodies are nearly vertical and very irregular in cross-section. Stoping is done by slicing and filling at some places, and by shrinkage at others. The ore is too soft to stand without support, and timbers are extensively used. The first slice of any stope is horizontal, but the back often becomes inclined as stoping proceeds, and may vary considerably in elevation. It was sought to obtain accurate horizontal cross-sections of the shoots at regular intervals. Owing to interference of these timbers and to the small vertical space in the stopes, it was impossible to use the theodolite for surveying these contours. There were also the difficulties incidental to connecting stope surveys with development surveys through long narrow passes, and the necessity of employing Kafir assistants who could not be trusted to work reliably at more than 20 ft. from the observer. In the method finally adopted the hanging compass and clinometer were used for the necessary traverses and the polar protractor for details. We give herewith a short description of the field work, but we have not space for an account of the office work or for a discussion of the limits of application and the accuracy of the method. Nor have we space to reproduce the illustrations.

Copper nails with numbered tickets are driven into the timbers at the bottom of the manways of the cribbed passes, generally at a corner. The nails are connected to the survey of the level and their elevations determined. In the stope, any convenient pass is taken as a starting-point for the survey. A numbered copper nail is driven into the timbers in the same relative position as the nail below, and the distance between the nails measured. The passes can usually be treated as truly vertical without material error, but, if necessary, any deflection is easily determined by the use of a plumb-line or clinometer for inclination, and the compass for direction. From this upper nail, stout twine, 100 ft. or more in length, is ranged round the stope, as a closed traverse, or to the reference nail in the next convenient pass. Supports for the string are provided by means of ordinary nails driven into the timbers, wedges driven into cracks in the rock, or long pegs driven into the day's drill-holes. Supports are considered stations, and the lines are deflected as much as necessary to give the most effective positions. Between stations the lines are drawn taut, and care is taken that they foul nothing. The stations may be as close together as necessary, but should not be more than 25 ft. or 30 ft. apart, in order to avoid excessive sag, and to keep the effect of any error made a reading, whether due to carelessness or local attraction, at a minimum.

The compass is hung on the line at a convenient point, with the whole-circle zero forward in the direction of the traverse. The north-seeking end of the needle is read as a continuous bearing to a $\frac{1}{4}$°, when all steel, such as hammers, drills, shovels, picks, etc., has been removed to fully 20 ft. from the instrument. Steel-buckled belts are avoided, but it is found that the nails in mine boots cause no apparent deflection if the feet are kept vertically below the compass, or in line with the needle. After removing the compass, the clinometer is hung at each end of the line in turn, about 18 in. from the supports, and both readings of inclination noted. There is a difference between the readings due to sag, varying with the tension of the string and the distance between stations.

Local cross-sections of the stope are then taken by means of the polar protractor. This instrument, though simple, is little used by mine surveyors, and the modified form adopted warrants description: A circular piece of 16 S.W.G. sheet brass, 8 in. diam., is marked on one side at every 5° from 0° to 360° in cyclic order. The first and fourth quadrants have the central portions removed, and from 180° to the centre a slit is cut which is just equal in width to the diameter of the string used. The protractor is placed in position by passing the slit over the string, when it will hang in a vertical plane which is at right angles to the vertical plane of the traverse line, and the zero of the protractor will be vertically over the string at its centre. Any tendency of the protractor to slide along steep lines is easily counteracted by the compass clips. The cross-sections are taken at every significant change in the shape of the stope. The protractor is hung on the line so that the graduations face the observer, who looks in the direction of the traverse. The ring of a linen tape is fastened by a spring hook to the end of a light extensible rod, and by means of the rod an assistant holds it, in turn, on the salient points in the cross-section desired. The tape is drawn taut and held in front of the protractor, just touching the string. The observer then reads the inclination and length of the offset, keeping the tape in the correct plane by noting that it is parallel to the protractor. The offsets are limited in length on account of (1) sag, (2) difficulty of adhering to cross-section plane, and (3) magnification of errors due to reading incorrect inclinations; and they should not ordinarily exceed 12 ft. The distances of the cross-sections along the traverse line are noted, and for this purpose it is convenient to lay previously a special draft tape along the line, with its end fastened to the point of commencement." — WILLIAM WHYTE, Institution of Mining and Metallurgy. — *Mining Magazine*, May, 1917, p. 272. (E. M. W.)

MISCELLANEOUS.

THE EXPLOSIBILITY OF ACETYLENE. — "In this report are shown the results of experiments made by the Bureau of Mines to determine the limits of complete propagation of flame in mixtures of acetylene and air.

The term 'limits of complete propagation of flame' is used by the authors to designate the lowest and highest percentages of a combustible gas in mixture with air that permit combustion to spread through the mixture from any given point of ignition. Propagation of flame then takes place from point to point or layer to layer throughout the mixture without any necessity for the continued presence of the source of heat that starts the inflammation.

Acetylene is used extensively as an illuminant in miners' lamps. For this reason and because of the ease of generation of the gas from water and calcium carbide it seemed desirable to present a study of the possibilities of explosions occurring when the carbide is being handled in mines. An additional reason lies in the different results obtained by different investigators in determining the inflammable limits of mixtures of acetylene and air, as is shown by the following table :—

Inflammable Limits of Acetylene Mixtures as Determined by Various Investigators.

Name of Investigator		Low limit of acetylene content *Per cent.*	High limit of acetylene conteot *Per cent.*
Teclu*	. ...	1·53 to 1·77	59·95 to 58·65
Bunte†	...	3·35	52·30
Clowes‡	.. ...	3·00	82·0
Le Chatelier**	...	2·8	65·0

Comments on Investigations of Others.—Teclu conducted his experiments in a glass cylinder 14 mm. wide. A platinum spark gap was placed near the top. Teclu's results on the inflammable limits of various gases have been criticised by Burgess and Wheeler,* by Coward and Brinsley,† and by Parker.‡ Parker thought that Teclu did not allow sufficient time for the gases to mix before sparking them. Bunte conducted his experiments in a burette of 19 mm. diameter over water. Ignition was effected by an electric spark. Clowes conducted his experiments in a glass cylinder 3 in. in diameter and closed at one end. Ignition was effected from above with a Bunsen flame.

Of much interest are further experiments performed by Le Chatelier** on the propagation of flame in glass tubes of small diameter. The limits of inflammability for different sizes of tubes as determined by Le Chatelier, are as follows :—

Limits of Inflammability of Acetylene-Air Mixtures in Tubes of Different Sizes.

Diameter of Tube. *Mm*		Proportion of acetylene for low limit. *Per cent.*	Proportion of acetylene for high limit. *Per cent.*
0·5	... ...	—	—
0·8	... .	7·7	10·0
2·0	... . .	5·0	15·0
4·0	... ..	4·5	25·0
6·0	... .	4·0	40·0
20·0	... .. .	3·5	55·0
30·0	... .. .	3·1	62·0
40·0	... . ..	2·9	64·0

Bearing of Conditions on Results of Experiments.—Work by the authors and others on the limits of complete propagation of flame in mixtures of combustible gases and air has shown that the results obtained are much affected by the conditions of any given experiment. Differences obtained are due to (1) the use of vessels so small that they allow too great heat absorption by the containing walls; (2) differences in method of igniting the mixtures—whether from the bottom upward or from the top downwards; (3) improper mixing and analysis of the gas mixtures; (4) to a lack of proper conception of the term 'limit of complete inflammation"; and (5) because the distance traversed by the flame has not been sufficient to prove that it will travel indefinitely through the mixture after its propagation has become independent of the initial impulse of the igniting arrangement. In the experiments reported herein the authors have endeavoured to avoid the errors mentioned. The use of a large box of 130 litre capacity and 1 sq. ft. cross section eliminated some of the most serious sources of error.

Preparation of Acetylene.—Acetylene for the author's experiments was prepared by the action of water on calcium carbide such as is furnished miners for use in their acetylene lamps. Analyses were made as the various mixtures were prepared for experiment. The analytical data covering the analyses of one mixture of acetylene and air follow. The determination was made by igniting a measured quantity of the mixture with a hot platinum spiral.

---

* Teclu, N., Zur Ermittelung von Explosionsgrenzen in Gasgemengen (Contribution to the subject of the determination of explosive limits of gas mixtures): *Jour. prakt. Chem.* Bd. 75 1907, pp. 212-223.

† Bunte, H., Uber Explosive Gasgemenge (Explosive Gas Mixtures); *Jour. Gasbel.*, Bd. 44, 45, 1901, pp. 835-842.

‡ Clowes, Frank. The Limiting Explosive Proportions of Acetylene and Measuring the Gas in the Air: *Jour. Soc. Chem.*, Ind., vol. 15, Oct. 31, 1896, p 701.

** Le Chatelier, H., Sur lu Combustion de l'Acétylène (On the Combustion of Acetylene): Compt. rend., t. 121, 1895, pp. 1144-1147.

* Burgess, J. M., and Wheeler, R. V. The lower limit of mixtures of the paraffin hydro-carbons with air: *Trans. Chem. Soc.*, 1911, vol. 99, pp. 2013 2030.

† Coward, H. F., and Brinsley, Frank. The dilution limits of inflammability of gaseous mixtures: *Jour. Chem. Soc.*, vol. 106, July, 1914, pp. 1859-1885.

‡ Parker, Albert. The lower limits of inflammation of methane with mixtures of oxygen and nitrogen: *Jour. Chem. Soc.*, vol. 105, April, 1914, p. 1002.

** Le Chatelier, H., Sur la Combustion de l'Acetylène. Compt. rend., 1, 121, 1895, pp. 1144-1147.

Results of Analyses of an Acetylene-Air Mixture.

Item.	Analysis 1 C.c.	Analysis 2 C.c.
Sample taken	49·90	50·10
Air added	0·00	9·90
Total volume for combustion	49·90	60·00
Volume after combustion ...	47·85	57·80
Contraction due to combustion	2·05	2·20
Volume after KOH absorption	45·10	55·00
Carbon dioxide produced by combustion	2·75	2·80
Proportion of acetylene (from carbon dioxide), per cent.*	2·76	2·80

* Per cent.

A part of the same sample was also analysed by causing the acetylene to be absorbed in bromine water. By this method there was obtained 2·88% acetylene, a good check on the combustion method of determining the acetylene.

Tests to Determine Low Explosive Limit of Acetylene-Air Mixtures.—The results of tests made to determine the low limit of complete inflammation in a Hempel glass explosion pipette follow. The pipette was spherical and had a capacity of 100 cc. Entering near the top were two platinum wires, across which a spark could be passed from an induction coil driven by dry cells.

Results of Experiments to Determine Low Limit of Complete Propagation of Ignition in Acetylene-Air Mixtures in the Hempel Pipette

Test No.	Proportion of acetylene. *Per cent.*	Result of observation.
1	2·78	No visible effect.
2 ..	2·82	Do.
3	3·00	Complete inflammation.
4 .	3·19	Do.

From the above tests there was found as the low limit a value between 2·82% and 3·00% acetylene.

The products of combustion after each test were analysed. The carbon dioxide resulting from test 1 was 0·20% of the mixture. The carbon dioxide after test 2 was 0·25%. The carbon dioxide after test 3 was 5·79%, equivalent to 2·90% acetylene, showing that practically all the acetylene burned to carbon dioxide and water. The carbon dioxide after test 4 was 6·11%, corresponding to 3·06% acetylene.

The low limit was next investigated in a larger explosion vessel. The vessel had a capacity of 2,800 cc. Two copper wires entered through the sides and met in the centre of the vessel. A current of 5 amperes at 220 volts was passed through the wires. Ignition of acetylene-air mixtures inside the jar was brought about by drawing the two wires apart while the electric current was flowing, thereby producing an electric spark. The results of the tests were as follows :—

Result of Tests to Determine Low Limit of Mixtures of Acetylene and Air in an Explosion Vessel of 2,800 cc. Capacity

Test No.	Proportion of acetylene. *Per cent.*	Results of observations.
1	2·81	Incomplete inflammation. Flame travelled for 1 to 2 in. above the terminals, but did not spread throughout the mixture.
2 . .	2·98	Do.
3	3·07	Complete inflammation. Flame spread throughout the mixture.

The experiments showed that complete propagation of flame was obtained when the proportion of acetylene was between 2·98% and 3·07%.

Experiments on the low limit was next made with a box made of glass and wood, having a capacity of 130 litres and a cross section of 1 sq. ft. The front and rear of the box were made of glass, so that the propagation of flame, when this occurred, could be observed. A motor-driven fan at the bottom of the box mixed the gases. A sheet of paper was used to cover the top of the box. The source of ignition was an electric flash produced by drawing two copper wires apart, as in the preceding tests. Ignition was started both at the top and the bottom of the box. The results of the experiments follow :—

Results of Experiments to Determine Low Limit of Mixtures of Acetylene and Air contained in a 130-litre Box.

Ignition from Bottom Upward.

Test No	Proportion of acetylene. *Per cent.*	Remarks.
1	2·42	A flame about 1 in. wide travelled 2 in. above the source of ignition.
2	2·42	Do.
3	2·50	A flame about 1 in. wide travelled 1 ft. above the source of ignition.
4	2·50	Do.
5	2·53	The flame travelled to the top of the box.
6	2·53	Do.
7	2·67	Do.
8	2·73	Do.

Ignition from Top Downwards.

Test No	Proportion of acetylene. *Per cent.*	Remarks.
1	2·52	The flame did not travel downward.
2	2·62	Do.
3	2·68	Flame travelled 1½ ft. downward.
4	2·87	Flame travelled downward the length of the box.
5	3·11	Do.

The results of the foregoing experiments show that the complete propagation of flame was obtained upward through the box with a mixture containing 2·53% acetylene. Propagation downwards was not obtained with less than 2·87% acetylene.

Experiments to Determine High Explosive Limit of Acetylene-Air Mixtures.—Experiments were also performed having to do with the high limit of acetylene-air mixtures. The results of experiments made in the Hempel explosion pipette follow :

Results of Experiments to Determine High Limit of Complete Propagation of Flame in Acetylene-Air Mixtures in Hempel Pipette.

Test No.	Proportion of acetylene. *Per cent.*	Results of observations.
1	58·66	No observed effect, except small deposit of carbon near terminals.
2	56·44	Do.
3	55·14	Do.
4	54·14	Do.
5	53·42	Do.
6	52·63	Do.
7	51.72	Do.
8 . ..	50·00	Complete inflammation with a heavy deposit of carbon all over inside of pipette.
9	49·53	Do.

The experiments showed that under the conditions the high limit of complete propagation of flame of acetylene-air mixtures was between 50% and 51·72% acetylene..

Further experiments were performed on the high limit with the 2,800 cc. vessel. The copper wires carrying the current met at a point close to the bottom of the jar, so that inflammation could be originated at the bottom of the mixture. The results follow :—

Results of Experiments to Determine Upper Limit of Complete Inflammation of Acetylene-Air Mixtures with a Current of 5 amperes at 220-volt Pressure as a Source of Ignition.

Proportion of acetylene, *Per cent.*	Remarks.
51·3	Complete propagation of flame.
52·4	Do.
53·4	Do.
59·5	Do.
63·5	Do.
73·0	Do.
75·2	Narrow flame travelled to top and was extinguished. When the electric flash was applied for a second time, complete propagation with a loud report followed.
76·3	Narrow band of flame travelled to top of jar. Did not spread to sides.
77·1	No propagation of flame. Slight inflammation around terminals of wire.
78·3	Do.

Under the different conditions of the experiments widely different results were obtained. With the Hempel pipette an upper limit close to 50% acetylene was found, and with the 2,800 cc. vessel an upper limit close to 73% was established. It seems, then, that the upper limit is much affected by the conditions of experiment, a fact that probably explains why widely different results have been obtained by different investigators. The wooden box used in some of the preceding tests was not considered strong enough to withstand the explosion of large percentages of acetylene, and therefore was not used to determine the upper limit of acetylene-air mixtures.

Liability of Acetylene-Air Explosions in Mines.—With the increasing use of acetylene in mines there has arisen the question of the danger of its exploding in the mine from various causes. There may first be considered the quantity of calcium carbide necessary to furnish explosive proportions of acetylene. Four and six-tenths (4·6) cubic feet of acetylene from one pound of calcium carbide may be considered a good yield. Four and six-tenths cubic feet of gas would render 182 cubic feet* of air explosive on the basis of the low explosive limit of acetylene-air mixtures being 2·53% acetylene under the ideal condition that the acetylene be uniformly mixed throughout such a space and confined to it. Such an accident as the dropping of calcium carbide in a pool of water on the floor would result in a rich mixture near the water, the mixture gradually becoming leaner, of course, as the acetylene diffused into the air or was swept away by the ventilating current of the mine. The ignition of acetylene produced under such conditions would result in the formation of a flame confined to a much smaller space than in the dimensions given.

The calcium carbide in a miner's lamp (about 50 gm.), upon contact with water, would produce 0·51 cub. ft. of gas. This quantity would render about 21 cub. ft. of air explosive if the acetylene could be confined to a space of that size. However, such a condition is not probable.

Formation of Acetylene from Loose Carbide.—There remains to be considered the formation of acetylene from the action of the moisture in the mine air on calcium carbide that might be thrown on the floor of the mine. A room 18 ft. wide by 30 ft. long by 7 ft. high would contain 3,780 cub. ft. of air. In this space, if the temperature was 65° F. and the saturation 90%, there would be contained 1,495 gm. of water. One thousand four hundred and ninety-five (1,495) grams of water would be enough for complete reaction with 2,660 gm. of calcium carbide and would produce about 27·0 cub. ft. of acetylene. The production of acetylene in this manner would be too slow, however, to form an explosive mixture with air, because the acetylene first formed would be continuously carried away by diffusion and air currents, and consequently there would not result the accumulation necessary to form an explosive mixture.

On the whole, with reasonable precaution, there need be little danger from explosion of acetylene in mines. That such an explosion may happen, however, is shown by a coal-mine accident, the details of which were as follows :—A miner carrying calcium carbide in a glass bottle stumbled and fell. The bottle broke, throwing the carbide into some water on the floor. Acetylene was immediately generated and was ignited by the miner's cap light, severely burning him. Such an accident is a rarity.

Explosibility of Acetylene under Pressure.—Several experiments were made in order to determine the effect of pressure on the explosibility of pure acetylene, as follows :—

Acetylene, not mixed with air, was enclosed over mercury in a 100 cc. glass vessel and its pressure slowly increased by means of a column of mercury until a maximum of 5 atmospheres pressure was obtained. No explosion resulted. The experiment was twice repeated, and each time under a pressure of 5 atmospheres a mild explosion with the formation of much carbon resulted when a platinum coil in the gas was electrically heated to a white heat.

Under the same conditions of experimentation, except that a small electric spark from an induction coil was used as the source of ignition, the gas exploded with great violence at a pressure of 3 atmospheres.

Experiments were then made to determine the effect of increased initial pressure on the low explosive limit of acetylene-air mixtures. It was found that with an initial pressure of as much as 5 atmospheres the low limit obtained, between 2·82% and 3% acetylene (ignition from the top), is not different from the value obtained with an initial pressure of 1 atmosphere.

When acetylene was mixed with air so as to form 10, 20, 30, 40, 50, 60, 70, 80, and 90% acetylene mixtures no explosion resulted from compressing the mixtures to 1, 2, 3, 4, and 5 atmospheres. No means of ignition, such as an electric spark or a heated platinum wire, was used.

Summary.—The authors' experiments showed that the smallest proportion of acetylene capable of propagating flame in a mixture of acetylene and air was 2·53%.

---

* One hundred and eighty-two (182) cubic feet of air would be contained in a room 6 feet wide, 6 feet high, and about 5 feet long

The largest proportion of acetylene capable of propagating flame in a mixture of acetylene and air was found to be about 73%.

Acetylene, not mixed with air, is explosive under a pressure of 3 to 5 atmospheres when an electric spark is passed through the mixture or when a platinum spiral is heated in it.

The danger connected with the handling of calcium carbide in a mine is remote if reasonable care is observed in handling."—G. A. Burrell and G. G. Oberfell, Report, Bureau of Mines, Washington.—*The Engineering Review*, July 15, 1916, p. 17. (J. E. T.)

Abstracts of Patent Applications.

176.17. William George Gibson. Improvements in apparatus for separating and detaining metals from liquid matters. 16.4.17.

This application relates to apparatus for separating portions of metal or other heavy substances from liquids by means of gravity.

196.16. James Whitehouse (1), John Peel Nelson (2), Frank Robinson (3). Improvements in shaft gates. 8.8.16.

This application relates to improvements in cases where men are raised and lowered from a mine shaft in cages having several decks, more particularly to apparatus which will control the movement of the gates giving access to the various decks from a gate controlled by the onsetter. The application also makes provision for throwing out the starting signals when the gates controlled by the onsetter are open.

204/17. Rhitherford Brawdus Martin. Improvements in ore concentration. 23.4.17.

This application describes a process of concentrating ores, oxides or carbonates of copper particularly by froth flotation. The applicant claims to have found a means of treating the oxidised or carbonate copper mineral with a solution of a polysulphide, whereby the mineral is floated, although no visible film of sulphide is formed on such mineral.

205.17. Herbert Charles Colburn (1), Ernest August Colburn (2). Process of and apparatus separating valuable particles of finely divided ores.

This application relates to a process and apparatus for separating minerals by flotation. It appears to aim at effecting a cleaner separation than is obtainable by other known methods.

227.17. Jens Jakob Lassen (1), Vilhelm Frederick Hjort (2). Improvements in or relating to the outlet or extraction pipes of filters. 5.5.17.

This application relates to an improved outlet pipe from filters and comprises a cup or trough over which is placed a cover extending beyond the edge of said cup and a perforated screen, so arranged that the filtered liquid passes upwards through the outer portion of the screen and downwards through the centre. The drawings show various types of this device.

234.17. Arthur Gordon. Improved method for precipitating gold. 10.5.17.

This application is for a process patent on precipitating gold from aurocyanide solutions by means of the hydrogen evolved by aluminium amalgam in cyanide solution. This amalgam is prepared by introducing aluminium shavings into a 1% solution of mercuric chloride.

244.17. Askin Morrison Nicholas. Improved process of separating liquids from solids. 12.5.17.

This application is for a process patent for use with a special design vacuum filter, principally for ore slime.

In order to understand the process, it is necessary to describe the apparatus used. This is a cylindrical rotating drum, to the inside periphery of which is attached the filtering medium or fabric. The material or pulp to be filtered is fed continuously to the lower inside part of the drum, vacuum is applied, and the solids are discharged by reverse intermittent air or water pressure when during the drum's revolution they reach an inverted position. The pulp fed classifies according to specific gravity and size, making a cake of diminishing porosity from the bottom to the top.

251.17. Askin Morrison Nicholas. An improved apparatus for separating liquids from solids. 15.5.17.

This application is for an apparatus patent for a continuous vacuum filter of the revolving drum type used in connection with filtering ore slime.

The apparatus consists of a hollow cylindrical rotating drum on the inside periphery, of which, called an annulus, are arranged the filtering cells. The material or pulp to be filtered is fed continuously to the lower inside part of the drum, vacuum is applied, and the solids are discharged by reverse air or water pressure, preferably applied in jerks, when, during the drum's revolution, they reach an inverted position. If desired, to assist filtration, a thin layer of sand or some porous material can be laid down ahead of the regular feed.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

Brown, A. H., *l/o* Cobalt: 133, Kent Street, London, Ontario, Canada.
Dewar, T. N., *l/o* Maraisburg: Brakpan Mines, Ltd., P.O. Box 3, Brakpan.
Hodges, I., *l/o* Capetown; P.O. Box 82, Vereeniging.
Leitch, Q. J., *to* P.O. Box 25, Cleveland.
Mather, T. W., *l/o* South America: c/o Messrs. Guggenheim Bros., Room 3533, 120, Broadway, New York.
Maxwell, F. A. G., *to* P.O. Box 1242, Johannesburg.
New, W. Stanley, *l/o* Randfontein: Green Hill Park, Evesham, England.
Russell, W., *l/o* Ross Hill: Nourse Mines, Ltd., P.O. Box 32, Denver.
Wilson, G. C., *to* Reduction Department, Springs Mines, Ltd., Springs.

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII. SEPTEMBER 1917. No. 3.

Proceedings
AT
Ordinary General Meeting, September 15, 1917.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building on Saturday, the 15th September, 1917, Mr. G. Hildick-Smith (President) in the chair. There were also present:—

26 Members: Messrs. H Meyer, A. Whitby, H. A. White, J Chilton, J. Gray, C. Toombs, F. W. Watson, J. Watson, Dr. W. A. Caldecott, A. McA. Johnston, W. R. Dowling, Prof. G. H. Stanley, J. E. Thomas, Prof. J. A. Wilkinson (Members of Council), R. W. Bennett, A. King, P. T. Morrisby, S. Newton, J. D. Marquard, E. A. Osterloh, C. Rowe, C. B. Simpson, J. J. R. Smythe, J. A. Taylor, T. P. Waites.

4 Associates: Messrs. B. C. Forrest, H. Rusden, H. Ward, L. A. Womble.

5 Visitors, and Fred Rowland (Secretary).

MINUTES.

The minutes of the Annual General Meeting, held on the 23rd June, 1917, as recorded in the June *Journal*, were confirmed.

ELECTION OF NEW MEMBERS.

Messrs. J. Watson and A. Whitby were elected scrutineers, and after their scrutiny of the ballot papers, the President declared the following gentlemen unanimously elected to membership:—

Beaumont, Rolland, Bantjes Consolidated Mines, Ltd., P.O. Box 2, Florida. Mining Engineer.
Couperthwaite, J., Brakpan Mines, Ltd., P.O. Box 3, Brakpan. Mining Engineer.
Little, Thomas, Crown Mines, Ltd., P.O. Box 106, Crown Mines. Underground Manager.
Macfarlane, Rienzi W., P.O. Box 674, Morenci, Arizona, U.S.A. Mining Engineer.
Mitke, Charles A., P.O. Box 2051, Bisbee, Arizona, U.S.A. Mining Engineer.
O'Reilly, Reginald Edward, Pilgrims Rest Consolidated Goldfields, P.O. Box 88, Pilgrims Rest. Metallurgist.
Price, Bernard, Victoria Falls and Transvaal Power Co., Ltd., P.O. Box 2671, Johannesburg. Chief Engineer.
Selby, Paul, Ferreira Deep, Ltd., P.O. Box 1021, Johannesburg. Mine Manager.
Thorlund, Johannes, P.O. Box 4363, Johannesburg. Mining Engineer.
Wonnacott, Richard Henry, Government Miners' Training School, P.O. Box 22, Florida. Acting Superintendent.

The President: Will you all try and obtain as many new members as you can? If we can keep up this speed, I think we shall show an increase in membership by the end of the year.

The Secretary: I might also mention that the following gentlemen have been admitted as Associates:—

Exter, Julius Karl, Government G.M. Areas, Ltd., P.O. Box 28, Brakpan. Assayer.
Moon, Cyril Leslie, Crown Mines, Ltd., P.O. Box 103, Crown Mines. Metallurgist.
Thorburn, Frederick Harrison, Nigel G.M. Co., Ltd., Nigel. Assayer.

As Students:—

Harding, E. G., P.O. Box 214, Germiston. Student.
Lange, Selig Abraham, S.A. School of Mines and Technology, P.O. Box 1176, Johannesburg. Student.

JOINT MEETING.

The President: The next matter I would like to bring to your notice is that of the Special Joint Meeting of members of this Society with members of the S.A. Institute of Electrical Engineers

The Joint Meeting is to be held on Saturday, the 29th September, at 8 p.m. As the details of the work of a promising local industry—that of the manufacture of shoes and dies from scrap—will be brought to our notice, I think we should all attend the joint meeting and hear what is being done, and thus be encouraged to support local industry. It is interesting to note that some of the members of this Society have been responsible, to a great extent, for this electric furnace manufacture of shoes and dies.

MEMBERS ON ACTIVE SERVICE.

The President: I want at this point to refer to the promotion of one of our members, Mr. Ralph Stokes, who is now a Lieut.-Colonel and Controller of Mines of the 1st Army. He received the Military Cross some time ago, and has since gained the D.S.O. Another gentleman, Lieutenant H. B. Williamson, of the City & Suburban, has also gained the Military Cross.

APPEAL FOR PAPERS

The President: As this is our first meeting for the year, I would like to call members' attention to the fact that we can always do with papers, especially at these times when many new ideas are being tried with a view to economising in stores by the use of scrap material and what not, and it will help others, I am sure, if as many of these ideas as possible are made known through the medium of this Society's *Journal*.

The President: I will ask Mr. White, as Vice-President, if he would be good enough to take the Chair while I deliver my address.

Mr. H. A. White *(Vice-President)* then took the chair.

PRESIDENTIAL ADDRESS.

By G. Hildick-Smith, B.Sc.

I wish again to express my appreciation and thanks for the honour you have done me in electing me your President for the year.

You will have received, with the usual Calendar Card for the year, a circular letter, which I thought might perhaps encourage some members to pull a little more than their usual weight for the good of the Society and indirectly for the good of the Mining Industry during these serious times. It is essential for the gold mining industry to be carried on during the period of the war, and this it is fast becoming increasingly difficult to do, especially in the case of the poorer mines. Without being unduly pessimistic, it must be admitted that many mines are already having a very hard struggle for existence, and it is possible that several mines will not survive this period of unduly high costs, while in the case of others the issue is still in doubt, and is dependent upon what extra burdens the Industry has to bear. The seriousness of the present time is not, I am afraid, yet sufficiently realised here: if it was, I am sure we should all be more careful than we are at present, to economise in every way both in our own private affairs and also in matters appertaining to our work. It is with regard to my own branch of the latter that I have been thinking with a view to writing something as my so-called Presidential Address, and the following remarks are the result:

The world war has, amongst other things, shown and emphasised the want of co-ordinated and systematic research work in all the various branches of industry existing in the British Empire, and already this fact is becoming generally realised. Taking this then as an axiom, I have endeavoured to show the need for research work as one means for further improving the efficiency chiefly of the underground work—although the same applies to a greater or less extent to other departments of the mines of this important mining field. To begin with, ideal conditions exist here for the carrying out of research work as there are, in a comparatively small area, a large number of mines mostly controlled by the mining houses, in such a way as to give ample scope for valuable research work on the mines of any one group and, apart from that, the interest of these mines as a whole are also promoted by the Chamber of Mines. At the present time in the mining industry, directors, consulting engineers, mine managers and others on the mines, have, on the whole, more than enough work to do to make it possible for any of them to concentrate sufficiently on the scientific investigation of any one problem, and follow it to a final conclusion. This is in itself beginning to place the mining industry at a disadvantage from an efficiency point of view, as, unfortunately, the general tendency is for the fringes of problems relative to the finer points of efficiency only to be touched, and conclusions have thus often to be assumed without definite proof; in the general rush of work important points are thus liable to be missed to the detriment of the industry. With reference to the underground work of the mines, it is unfortunate that in underground work the results obtained by the adoption of any one method of working or what not, cannot always be directly attributed to any special method employed, as many variable factors often enter into the calculations and therefore, before any definite conclusion can be arrived at, it will often be necessary carefully to investigate the result of the use of any one method of working under varied conditions possibly on several mines. There is amongst underground officials at the present time, in so far as their work is concerned, a concentration of effort in the interests of safety and health, all essential and most necessary work, but it must be admitted that in the concentration on these subjects we are beginning to sacrifice efficiency and hence profit. We have, I think, now arrived at a stage when this concentration of effort in the interests of safety and health must be offset by a more careful study of the finer points of efficiency in the hope that this study, combined with scientific investigation, may result in the application of methods which will so improve efficiency as to help in making it possible for many of the poorer mines to continue working and improve the results obtained at the richer mines.

Speaking from the point of view of a mine manager, the time has certainly come when the many duties of such a position make it impossible to concentrate for such time as is required for the scientific investigation of any one subject. In order to overcome this difficulty, which militates against the more efficient running of the mines, it is now necessary. I think, to so arrange the present system of group organisation as to permit of research work being done on the mines on subjects on which the management requires detailed information, and at the same time such work should be of a systematic and co-ordinated nature for the benefit of the mines as a whole; for this reason, under the present form of group organisation a research department as a branch of the consulting engineer's department would be necessary.

On the mines at present no officials are employed solely for the purpose of collecting detailed data on any subject for the better information of those by whom such definite data might be used to improve efficiency. Every official has, on the whole, his time so fully occupied in keeping in touch with his ordinary routine work that the careful study of one subject for any length of time is out of the question. When detailed data are required, referring to underground work, such are usually obtained from a more or less unreliable source, as the usual mine records, referring to the work of this department, are compiled from figures given in a more or less careless manner by men unfitted to give data from which the finer points of efficiency are capable of being judged. The basis of the data referring to underground work being unreliable in detail can only afford from a scientific investigation point of view a rough idea of what is actually taking place, for this reason such data are often relied upon to an extent altogether out of proportion to their accuracy. On the whole, this evil may not be economically possible to remedy, but by the employment of trained observers by a research department correct and detailed data referring to any one subject could be obtained and much valuable information gained, which in many cases could be used to effect more efficient working.

In any research department, however controlled, the first essential is that the officials of such department must be free from routine work, and have time to concentrate thoroughly on any subject being studied. The work done by a research department must not be expected to be obviously or all at once productive; for this reason it is naturally difficult for those controlling the mining industry to authorise the spending of money for the payment of the salaries of officials whose work might not be obviously productive, especially does this apply to the running of the poorer mines.

The work to be done by a scientific investigation department would not necessarily be all true research work in the usual sense, but would, to begin with, consist of the collecting and correlating of data on subjects connected with underground work. Such data having been collected and examined would, in most cases, in order to prove their correctness and render them complete, require some further detailed investigation work. This would be one way of leading up to the thorough examination of any one subject, and a further result would be the indication of the lines on which research work in the true sense should be done. Another source from which ideas as to what subjects require careful investigation would be suggestions made by those employed on the mines who feel that more detailed data than they have at their disposal on any subject would be of value. As an example of the class of work which might be done by a research department, I would instance the question of the saving of nitro-glycerine, which has been forced upon the industry owing to the war, and as a result of which it has been found that, by the use of explosives containing less nitro-glycerine, many mines are obtaining the same or, in some cases, improved efficiency in breaking ore. This example should serve as sufficient indication of the need of thorough investigation into many other questions.

I would ask those conversant with underground work reading these remarks to think of the several methods of doing any one class of work underground, and then ask themselves whether or not they know definitely which is the most efficient of the possible methods of doing it. If they do not know the right method, then why not? In most cases it will be because insufficient careful investigation has been done on the subject. Again, do they not think that such investigation of the subject would be worth doing? The finer points of efficiency connected with the breaking, development and transport of ore alone offer many problems, which for their complete elucidation require systematic and careful investigation, for which co-ordinated work would have to be done on many different mines before definite conclusions could be obtained.

Another branch of work which could profitably be undertaken by a research department, would be that of obtaining definite information as to the most economical class of stores and materials for use on the same kinds of work. Officials on the mines have often different ideas as to the best class of material to use for a certain class of work. These ideas are often based on very indefinite data without allowance being made for the way such material is treated in its use. The buying departments of the mining houses, for example, are continually being asked to purchase different materials for the same class of work. In some cases, of course, this is due to the different conditions under which the material is used, but in many cases one material would be proved to be the most economical and efficient in its use if really definite data were obtainable. The mines could, with definite information, save much money by the use of the most suitable materials for any class of work.

As an example of what is being done in another direction through research work for the improvement of efficiency, I would instance the work of the S.A. Institute of Medical Research, through which the efficiency of the underground native labourers has been improved by the prevention of pneumonia. Another example of the use of research work for the prevention of miners' phthisis is shown by the work done by the Chamber of Mines through its dust sampling department, as a result of which the underground conditions of the mines, in respect to the dangerous dust particles carried in suspension in the mine air, have been greatly improved. The work done by the British Government in the investigation of mining problems at their experimental station at Altofts, and by the French Government at a similar station near Loos should be noted.

In another direction, that of safety, we have the local Prevention of Accidents Committee running a Safety First campaign which, although organised on different lines from that of a research department such as suggested, is doing good work. If for the safety of the mines a committee is necessary to improve matters in this respect—in addition to the Mining Regulations—is it not fair to assume that in order to obtain the maximum efficiency an efficiency campaign is necessary, and, if so, this would best be carried out through the medium of a research department. It is assumed that the highest efficiency consonant with safety is always being aimed at on the mines, but in these days of high cost for stores and materials and an increase in other costs due to war, together with the multiplication of mining regulations a special effort for its attainment is more than ever essential. With regard to the mining regulations, although they are excellent in themselves, many of them, when strictly adhered to, must unfortunately decrease efficiency. These, therefore, require to be offset by the most efficient methods of working and time saving.

Unfortunately research work on mining problems, with the object of improving efficiency, is not so obviously necessary as is research work in other industries in which the use of an improved process, as the result of scientific investigation, may place one industrial firm ahead of all others in a special industry. This does not apply to gold mining, however, on account of the standard price of gold. As already mentioned, the results of the careful investigation of mining problems on being applied in practice for the improvement of efficiency although necessarily improving it, yet they might not obviously do so as variable factors would in some cases obscure the anticipated results.

It can be truly said, of course, that improvements in efficiency are continually being made on the mines as the result of experiences and through the ingenuity of those engaged in the industry—this Society, for example, can be instanced as having in some measure helped in this way as a medium for the dissemination of valuable data—but work in the interests of efficiency done in this way is too spasmodic and needs co-ordination. The fact that there are no secret processes in use in the gold mining industry leads perhaps to the idea in the minds of some people that systematic scientific investigation is unnecessary, or even, if necessary, it may be said why not let others pay for it? If systematic investigation is now necessary, and I think it is, then in the general interest such work should be done.

Having noted very broadly the points in favour of research work on the mines some of the arguments against it should be mentioned

It is easy with so many mines in close proximity to each other, to obtain information with regard to all the latest improvements relative to efficiency from all the mines. It is quite true that such information is available, but in many cases much of it is insufficiently known, even on the mines of the same group. When it is known, the information is often of an indefinite character, and the data available may have been obtained under entirely different conditions from those which obtain where it is hoped that similar methods may be profitably applied. In the mines generally, details of the various classes of underground work vary greatly, in some cases necessarily so, but in others the most effective methods of working could be definitely chosen and less efficient methods discarded, as the result of thorough investigation.

It may be said that such a suggested scheme for scientific investigation has already been tried, as instanced by the work in the past of the Mines Trials Committee, which did good work while it existed, but the members of this committee could not, however, give their whole time entirely to the investigation of any one subject and, therefore, their work could not be more detailed than that of the employees of the mines, who are doing their best in the investigation of problems in the short time they have to spare at present.

Again it may be said that in the event of of a research department existing the results obtained by it would not necessarily be agreed upon, or be essential to those whose work it would be to apply such results in practice. Against this argument we have the fact that proved scientific data cannot easily be explained away, and those who failed to make use of such data in practice would eventually find that their results of working were falling behind the general standard.

On the whole, it seems fair to assume that through the medium of a research department the efficiency of a group of mines could be improved, which would thus indirectly more than pay for the expenses of such a department. If a research department was formed it should, I think, commence its work in a small way, and gradually evolve a scheme to meet its requirements. For some time therefore little expense would be necessary other than the salaries of the investigators, as the mines for the greater part of the work would form the laboratories, and much of the investigation done would not necessitate extra expenditure. A scientific investigation department should issue information to those entitled to it, giving details of the work done and the results obtained in something of the same manner as the South African Institute of Medical Research is now doing. By the discussions on such information amongst those to whom it was of value for the improved running of the mines, and as is being done by the Prevention of Accidents Committee in their Safety First campaign, by the mines being periodically circularised in order to find out by whom the information was being made use of, and what results were being obtained by its use, improved efficiency could not help but result.

The war is, of course, causing abnormal conditions at present, and may continue to do so for some time: increased costs is one of the results of it, and it may therefore be said that the present is not the time for spending money unless such expenditure is obviously productive of a direct saving in other directions. Expenditure on scientific investigation may even now help those mines which, chiefly due to war, are struggling for existence, to tide over this difficult period and also be the cause of better results when times again become normal.

I think if the means were forthcoming for the establishment of a mining research department by any mining group on something of the lines broadly outlined, the technical employes of the mines would, on the whole, give it their support, and thus improve their own and the mines' efficiency.

Mr. H. A. White (*Vice-President*): It is not customary to discuss the Annual Address, and I suppose, therefore, we shall continue to follow our usual precedent and not discuss it in detail. But it is only fair to say that there can be no doubt that the support of our Society would be very heartily given in the direction that our President has suggested. I think also it is only correct to remark that the Mines Trials Committee died really in consequence of a lack of agreement as to the best way of running it amongst the various Groups. But I think it will be admitted by all that a great amount of valuable work was done and, as an instance of that, I can state that the tube mill practice on these fields is far and away ahead of anything else in the world, which fact is chiefly due to that Committee. I have to congratulate the President on his very excellent address.

The President: I thank you very much.

A LOGARITHMIC CALCULATOR.

By D. R. Robinson (Associate).

It has been kindly suggested to me that a brief description of my logarithmic calculator, for reducing planimeter readings of mine plans to tonnages and areas on the dip, might be of interest to members of this Society.

This instrument has been in use in several survey offices on the Rand for upwards of a year, and some of its users express themselves as delighted with its accuracy and the speed of working. Although essentially a circular slide-rule, in some respects it can lay claim to originality. It may possess some general interest for scientific men, in that a slide-rule of this form could be made up to deal with any formula having several variables and constants with no plus or minus signs.

The problem was to arrange logarithmic scales in such a way as to solve the equation:

$$T = \frac{K \times W \times P \times \mathrm{SecDip}}{12 \times n}$$

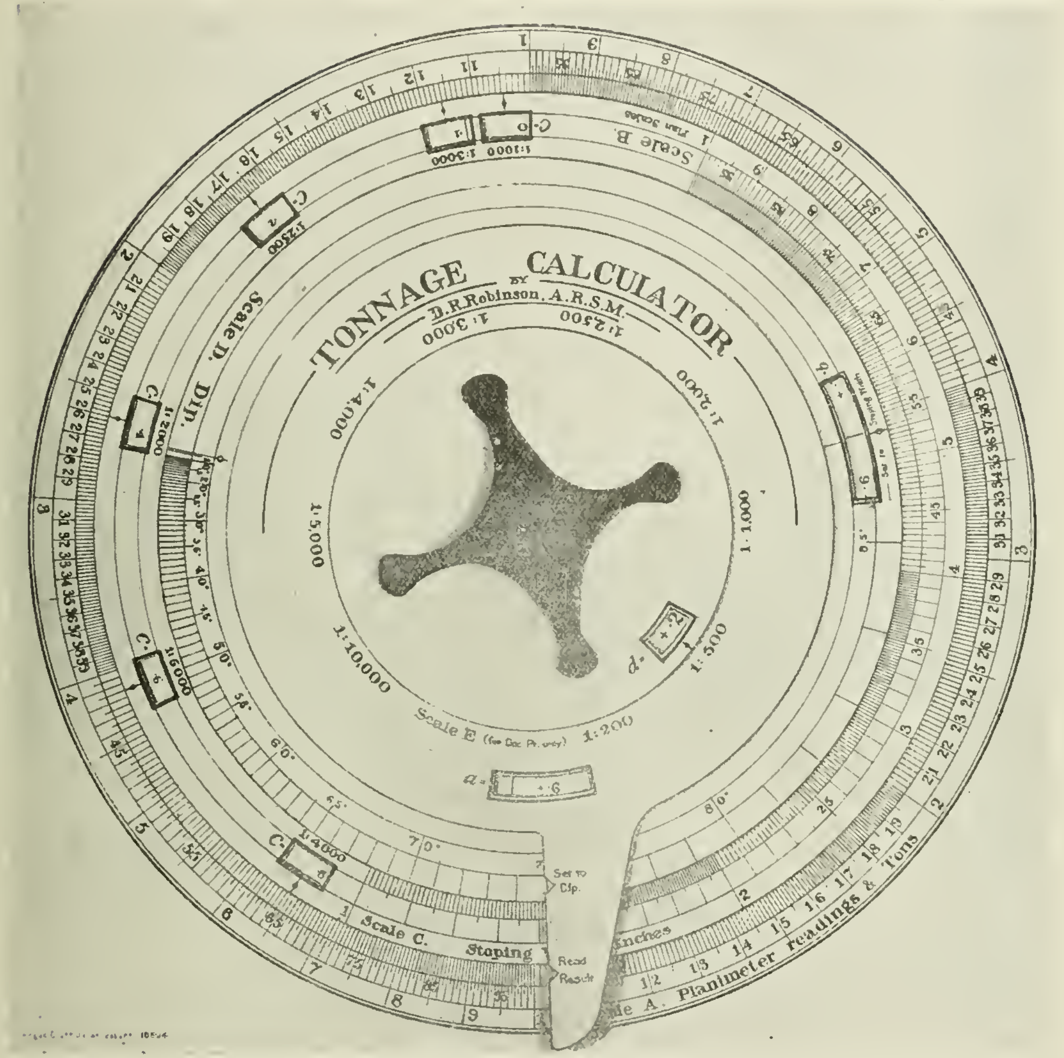
where T is tonnage, K is the number of actual square feet corresponding to a division of the planimeter vernier, W the stoping width in inches, P the planimeter reading, and n the number of cubic feet of rock in one ton.

These factors can be divided into three classes, viz.: (a) Variables, W, P, and SecDip; (b) Constant, the denominator 12; (c) factors that are constant throughout a series of operations, n and K. n is very generally taken as 12 on these fields, and was therefore included in class (b) as a constant, though it can be easily altered if desired. The value of K depends on the setting of the planimeter and the scale of the plan. The values of K used on the instrument are those corresponding with the usual natural scales, with a planimeter set to read one hundredth square inch on the vernier.

Looking at these three classes of factors, the principle at once suggested itself of combining a constant with a variable on each movable scale, so reducing the number of scales required. The circular form followed, in order to provide continuous reading; and the circle must contain the logarithmic scale twice, in order to make room for the constants. Having established these principles, it was a simple matter to arrange the equation on one fixed and three movable discs.

Referring to the illustration, the lowest disc carries a complete double logarithmic scale, reading from left to right, and serves for values of P and the result T.

The next disc contains a single logarithmic scale on one side, which is used for the stoping width; on the other side the logarithms of K are set off to the left from the origin of the stoping width scale. If one of these values of K be used as an index, and brought opposite the planimeter reading on the lower scale, clearly the stoping width will be opposite the sum, $\log P + \log K = \log W$, on the lower disc. Thus one constant



has been eliminated on the first movable disc. In order to mark off any new value of K on the disc, it is merely necessary to work out the actual square feet equivalent to one planimeter division, and by means of the lower scale measure the logarithmic angular distance of this figure round to the left from the beginning of the stoping width scale.

The third disc is arranged in a similar manner, to deal with SecDip and the product 144; but in this case the constant is a divisor, and therefore throws the reading index to the *right*. Since this would bring it into the midst of the scale of secants, the index was shifted through 180°, which makes no difference in the result, since the semi-circular scales are identical and continuous.

Above this disc a radial cursor is placed, used for reading the dip scale, with the result on the lowest disc. If the cursor is set to the dip, and the reading index is brought to the stoping width on the scale below, the effect is to multiply the product already obtained by $\frac{\text{Sec Dip}}{144}$, which completes the operation; and the cursor now reads the tonnage on the lowest disc.

In common with other logarithmic calculators, this one, as it stood, gave no indication as to the result representing tens or hundreds or thousands of tons; a device was therefore introduced which is believed to be an original feature. A small window was cut at each index mark, and underneath was printed a series of logarithms to one place of decimals, corresponding to the scale divisions read by such index. The logarithms of K were printed around the top of the cursor disc, as shown in the illustration. The constant 144 was shared between two discs, log 12 being deducted from the figures on each. Thus there are four figures appearing in the windows which, if added together and to the number of figures in the planimeter reading, give the logarithm of the result, +1; and neglecting the mantissa or decimal part, the integral part is the number of figures in the tonnage. This assumes a stoping width of between 10 in. and 100 in.; if it be greater, another figure must be taken in the result. The whole operation of thus fixing the decimal point takes about four seconds.

The discs are held friction-tight by a brass spring. If they are set from the top downwards, there is no danger of slip.

Inclined square feet are calculated as readily as tonnage, the only difference being that the figure 144 is taken instead of stoping width, which cancels the 144 divisor already allowed for. The result is identical with a tonnage having a stoping width of 144 in., so that an extra figure must be taken in the result.

In the same way a stoping width of 4 in. gives a reading equivalent to fathoms.

Various other operations involving allowance for dip can conveniently be done with the instrument. The results can be read to three significant figures at any part of the scale, four in some parts. To carry tonnage estimates further than this is not only unnecessary, but inaccurate, since neither the dip nor the stoping width nor the planimeter reading have anything like this degree of accuracy. The ordinary Amsler planimeter is usually taken to have a plus or minus error of 1%. The common practice of stating tonnages to a ton or even less has arisen from the universal use here of calculating machines of the Brunsviga type. These machines give us the figures whether we want them or not; and many people write them all down, thereby giving themselves considerable additional trouble when adding or multiplying. If the Brunsviga had never been invented, our surveyors would be using four figure logarithms and antilogarithms for this class of work, and we should not see such figures as 103,757·6 tons.

The President: We have to thank Mr Robinson for the note on his Logarithmic Calculator. I am sure he will be only too pleased to demonstrate its working after the meeting, to anyone who would like to go further into the subject.

I may say that this Calculator is very handy for quickly checking ore reserve tonnages, etc. I have used it myself for that purpose and, by working first with the Brunsviga machine, as Mr. Robinson mentions, and afterwards checking with the Calculator, much time can be saved.

NEW APPLICATIONS OF THYMOLPHTHALEIN AND NAPHTHOLPHTHALEIN, INCLUDING RAPID METHODS FOR ANALYSING LIMESTONE AND AMMONIUM SALTS.

By James Moir, M.A., D.Sc., F.I.C. *(Past-President).*

(Printed in Journal, February, 1917.)

REPLY TO DISCUSSION.

Dr. James Moir *(Past-President):* It has again, unfortunately, to be recorded that a chemical paper containing new matter and ideas has been passed over without discussion. I certainly expected that my attempt to bring limestone-analysis almost within the capacity of the office-boy would have been received at least with criticism! As it is, any reply to discussion is almost supererogatory—to use the language of Victorian literary swank.

However, Mr. John Watson has politely accused me of pronouncing the first *h* in "thymolphthalein." Now, I am not really sure whether I did so or not: but if I did, I think I can prove it to be quite justifiable on derivational grounds. Mr. Watson certainly cannot tell us why "thyme" is pronounced "time." I strongly suspect it is due to Teutonic influence, for the Germans go so far in their omission of *h*'s that they even omit *h* from such words as "naphtha," spelling it "naphta." Anyway, "thyme" is originally derived from classical roots with an ordinary "th" in them, such as *θυ*—(sacrifice) and *thur*—(incense), and the non-pronunciation of the *h* is a popular corruption sanctified by long usage, like "an orange" for "a norange" *(cf. naartje* with *norange).*

Popular usage is so strong that I daresay that in 10 years or so everybody here will similarly write "concensus of opinion," just because all our newspapers do so—apparently from want of a dictionary!

NOTES ON TREATMENT OF PILGRIMS REST ORE.

By ROBERT LINDSAY (Member).

(Printed in Journal, April, 1917.)

FINAL DISCUSSION.

The President: There are two contributions to the discussion on this paper of Mr. Lindsay's, printed in the August *Journal*, and I trust we shall have several more before the discussion is closed.

Mr. H. A. White *(Vice-President)*: Though the composition of this ore is very different from that of the Witwatersrand, yet the only constituent that demands a difference in treatment appears to be copper. From the author's statements and the analysis reported by Mr. A. F. Crosse it appears that the copper is not usually present as sulphide to any significant extent.

The author has pointed out the impracticability of acid solvents for removing the copper, but the possibility of using ammonia in some form deserves a thorough investigation. Some experiments made with artificial copper oxide indicate that ammonic hydrate has very little effect, but that the ordinary commercial "carbonate" of ammonia is a very ready solvent in dilute solution, and that sodium carbonate with any of the commercial salts of ammonia reproduces this effect. As the commercial manufacture of salts of ammonia is now a South African industry, this part of the subject is worthy of further consideration, especially as it apparently costs about 3 3 per lb. to produce the copper obtained. The difficulty that iron cannot be used to precipitate the copper dissolved in this way might be overcome either by exact acidification or more simply by the use of alkaline sulphide.

Tube Mill Plant.—It may be calculated from the gradings quoted that each tube produces 56 tons of – 90 grade per day from a total feed of about 90 tons per tube. After allowing for the smaller size of the tubes used it appears that much better work could be done by increasing the feed tonnage so that either one tube might be eliminated or very much finer grinding secured.

Sand Treatment.—Local experience has been that little is attained by circulating solution through a sand charge without precipitating the gold and an examination of the chart supplied indicates that probably the gold is all dissolved during the first five washes, and that the richest gold solutions go to "vat" No. 1, instead of to extractor boxes. It is therefore by no means clear that the method adopted has any advantage over the more obvious method of extracting and precipitating all the copper at the earliest possible stage of the treatment. The strength of cyanide used probably ensures the complete extraction of all the soluble copper in the ore, which figures show to be 0·07 lb. per ton of sand and 0·15 lb. per ton of slime.

Possibly the figure 6 lb. of lime per ton of sand added to top treatment vats is a misprint, and the author will clear the matter up in his reply.

In view of the literature on the subject, it would be interesting if we could have results of experimental addition of ammonia to the solutions employed as, no doubt, this has been tried in various ways.

One of the most interesting points in this paper is the extraordinary success obtained with slime solution clarifiers, which appear to be in every way superior to local methods. If the author would amplify this description in his reply, we should be much indebted to him; is there any peculiarity in his slime which renders this simple method possible, and are the resulting solutions as crystal clear as we find to be absolutely necessary here?

The considerable amount of detail renders this paper of great value, and it is hoped that the author's invitation to criticise will meet with a good response.

Mr. A. Whitby *(Vice-President)*: The matter I am particularly interested in is the analysis given by Mr. Maeer in the last *Journal*. He has gone to a great deal of trouble, I suppose, in returning his figures to the third place of decimals, and he works his total out at 100·02, but some of the metals which are given there are reported as metals instead of oxides, whilst he characterises his ore as being oxidized. For example, he has zinc worked out to ·037, copper ·006, lead ·013, bismuth ·024, arsenic ·136. I am positive no man living can get arsenic to the third place of demicals in the analysis of an ore. Following on arsenic, he has antimony ·171. Now, where does that final "1" come in? I am inclined to think if he had said: "One-eight," "One-nine," or even "One-six," he would be probably sufficiently near. But the point I want to make clear is that all these metals are given, and yet there is no oxygen for them, and yet he has over the 100%. They cannot be there as metals; they must be there as oxides. It is a very laborious analysis, I must admit, but I could not help, from the point of view of the practical chemist, drawing attention to it.

THE NATAL COALFIELDS—PHASES IN DEVELOPMENT.

By Wm. Taylor Heslop.

(Printed in Journal, May, 1917.)

DISCUSSION.

Mr. E. M. Weston *(Member of Council)*: Mr. Heslop's paper is most interesting and instructive, and the thanks of the Society are due to him for presenting it. He does not deal much with geological questions, but Mr. Gascoyne has enlarged on this matter. There is, however, one aspect that deserves attention, more particularly in view of the serious shortage of reserves of first-class coal in the known coalfields of Natal as disclosed in the author's paper and elsewhere. I believe the Vryheid district contains large reserves; but it is obvious that if, in a coalfield of 50 square miles, 90% of the coal is affected by dikes, the life of the mines must be alarmingly short. The question at once arises: what are the prospects of finding further coal deposits under the newer formations, and more particularly nearer the coast? For the effect of the failure of the coal supplies on Natal would be disastrous. No longer would the prosperity of Durban continue as a bunkering port, and the Municipality of Durban could no longer supply electric current more cheaply than any other town in South Africa. Trade and industry would be crippled and production become more expensive.

Whatever the exact geological age of the coal seams, two facts are apparent. First, they are underlain at a depth of several hundred feet by the Dwyka conglomerate, which serves as a marker underneath. Secondly, on the top they are overlain by the Ecca beds, which form the scarp of the Drakensberg Mountains, and which in places, as at Indwe, C.P., contain inferior coal beds. When in Natal recently, I made a few enquiries and observations, and my old friend and teacher, Professor Krause, pointed out to me, that there are immense areas in Natal undoubtedly containing coal measures probably at workable depth. No doubt the seams occur in basins. Between the Glencoe fields and Drummond, below Maritzburg, is one area. At Drummond, the granite crops out, and between here and the sea we have another area. To the north, along the coast, we have coal at St. Lucia Bay, and the Dwyka conglomerate is found outcropping near the coast, and about Malvern. The country rises steadily in elevation, and at about 600 ft. higher elevation we might expect to find the coal measures outcropping. There are, of course, faults, dikes, and rolls in the strata to be expected, and newer formations occur covering the coal measures. The whole neighbourhood of Ladysmith appears worth thorough investigation; but any boring that has been done has been inconclusive and carried out in a half-hearted manner. Thick dolerite sheets and dikes render systematic work absolutely necessary. This work of exploration is of national importance. The Government should, by compulsion, acquire the option of the mining rights for a distance of several miles from the railway in selected areas, and systematically bore the ground under competent geological direction, which could be found in Natal.

I should like to ask Mr. Heslop whether it is definitely known that no other seams occur below those now worked before the Dwyka conglomerate is reached? The author does not say what the average dip of the seams is, but I presume they are nearly horizontal. Regarding the methods of mining, could Mr. Heslop give some figures of the comparative cost of mining coal by cutters, as against hand work? I find such figures hard to obtain anywhere. It, of course, varies somewhat with the width of the seams. What is a fair shift's work undercutting in square feet for, say, chain, disc and bar cutters as against the percussive type?, and is the cut taken in the coal or sandstone. I quote below* figures of labour efficiencies on the various South African fields; but surely this factor depends largely on the number of cutters employed?

---

*The recently issued annual report of the Inspector of Mines for the Middelburg District of the Transvaal, for 1916, contains an interesting table showing the results obtained at several of the principal collieries in that district. According to Mr. Rowland B. Gascoyne, of Johannesburg, this comparative statement has the advantage of applying to collieries working the same seam over an area where the underground conditions and the system of working are similar throughout, with one exception, the method adopted being the pillar-and-stall. The stalls or bords are 20 ft. wide, and driven from 60 ft. centres. The seam of coal

The people of the world are just dimly becoming aware of the extent of some of the losses and waste of natural resources under unrestricted private exploitation. America and Europe have suffered enormously, especially in coal, gas and oil losses. That the reserves of low grade gold ores on the Rand were not permanently lost to a larger extent, has been due as much to the wonderful strength of the strata as to the skill employed in reclaiming them. Natal coal mines seem to present a bad example, and the circumstances seem to call for Government investigation and interference. Regarding the top seam of coal, the miner used to the Rand would be inclined to ask whether it would not be possible to mine both seams in one face longwall, and to use the parting to build packs large and solid enough to control the roof subsidence, but no doubt here the rock is too brittle and the packing too soft for such a method.

Unfortunately, collieries have no sand dump to send below, but it does seem a feasible scheme in the hilly and well watered country in which collieries occur to open out a hydraulic cut in a neighbouring hillside, or in an old ash or burnt out dump, and sluice enough filling underground to overcome all difficulties of working both seams, and of doing away with the expense and danger of gob fires.

---

runs practically level, and has a gross thickness of about 20 ft., but only the lowest portion is worked, the greater proportion of the seam being unsaleable coal. The portion worked varies from 3 ft. to 11 ft. The table referred to is as follows:—

Colliery.	Total men employed.	Coal mined per head per month.	Thickness Worked.
	No.	Tons.	Ft
Transvaal and Delagoa Bay ...	788	66 6	11
Tweefontein. ...	774	59·7	6
Cassel Colliery ...	482	56·0	6
Coronation	528	54·9	9
Witbank Colliery .	1,374	52 0	5¾
Middelburg Colliery ..	438	47·3	9
Oogies Colliery ...	1,199	39 3	3½

The most striking influence on the production per head shown in this table would appear to be that of thickness. At the Transvaal and Delagoa Bay colliery no coal-cutters are used, which makes the influence of thickness all the more striking. At the Oogies colliery, at the bottom of the table, the thickness of the seam extracted is only 3½ ft., and the average amount of coal mined per head per month is only 39·3 tons. To obtain this result at Oogies 70 coal-cutters are employed. The results at Oogies would further seem to show that, in the Transvaal, a 3 ft. seam of coal is as thin as can be worked by pillar-and-stall at a profit. In the Transvaal the use of coal-cutters generally increases the output by 50%. Last year 70% of the coal mined was produced by coal-cutters. A native, however, can rarely cut a length of 50 ft 6 ft. under in a day of nine hours. The average for the whole of the Transvaal is 48 tons per head per month. In Natal, where the seam worked averages only 4 ft. thick, and the coal is somewhat difficult to work on account of bad roof, gob fires and firedamp, the average is only 28 tons per head per month. In the Orange Free State, with a seam 7 ft. thick, but unusually hard, the average mined per month per head is 35 tons. In the Cape Province, where the collieries are small and the seams are thin, and carry more waste than coal, the average last year was as low as 7 tons per head; but here the collieries are often idle most of the time.

THE CONSTRUCTION AND MAINTENANCE OF SLIME DAMS.

Jas. E. Thomas (Past-President) and
E. A. Osterloh (Member).

(Printed in Journal, June, 1917.)

DISCUSSION.

Mr. S. Newton *(Member)*: Available ground and its situation govern methods of construction of dams for storing residue slime. Working conditions of the present day, or since the installation of the Butters' process of treating slime, have changed the conditions of storing slime. It is not necessary that the construction of slime dam walls should be of the same strength and nature as those constructed to hold water, even under the worst conditions. Slime of the right mixture makes excellent retaining walls if care is taken in building and local conditions are not against it.

The explanation by the authors of how to lay out the base walls and requisite channels is, no doubt, very similar to the present practice under similar surface conditions. In the early days it was very difficult to economically plan the general layout of the reduction works of a mine owing to the lack of knowledge as to the eventual magnitude of the property.

The storing of slime before the slime process eventuated, the general treatment of slime by the decantation process, the ever increasing percentage of slime made by finer grinding, tube milling with its increased sliming percentage, and eventually the Butters' process, bringing the per cent. of slime made to 60% of total ore crushed; all these have increased the difficulty. Then, local conditions of mine areas in the Central Rand, have a great bearing on the subject.

Where the ground dips south from the reef outcrop, and is the only ground available for storing slime residue, it is quite a different proposition to the description of an ideal dam as laid out by the authors:—"Two dams with a total circumference of 6,000 yards, built in the manner described would be sufficient to receive the slime from a plant treating up to 50,000 tons slime per month." This area is equivalent to about 337 claims, and almost equal to the combined claim areas of the Crown Deep and Langlaagte Deep.

In comparison, we have a total circumference of 6,000 ft., the base wall within close proximity to the main storm-water drainage from Johannesburg, the area enclosed being the site of old quarries, with nests of weeping springs of water, the bottom flat for about 400 ft., and then rising rapidly at a steep angle towards the reef outcrop; and having to contain from 70,000 to 80,000 tons of slime per month. Local conditions also govern cost of maintenance.

On fairly flat areas the maximum superficial capacity is obtained from the commencement; but on sloping ground, the available storage area is very small, the rapidity with which the base wall is built is not for the good of the wall itself, and by the time you have a large area for containing slime your base wall has reached a limit in height and another area has to be found.

Slime itself has also changed the conditions of building the dam walls. Slime from a decantation plant containing 3% +200, and equal to from 33% to 40% of total ore crushed is entirely different to 10% +200 and 60% of total ore crushed as from the Butters' plants decantation plant discharges, say, every ten hours and gives time for settling out, but the Butters' plant discharges regularly every 2½ hours.

With decantation slime it is necessary to keep sand in the slime channel to build with; in the Butters it is necessary to eliminate sand and retain slime. Later installations of Butters' plant have allowed for discharging direct from the hoppers to the sump where water may be added to bring pulp up to 50% moisture, and air agitated and so discharged in a condition most suitable for building and maintaining the walls. Where the slime is discharged direct from the hoppers to the dam and water is used to make the pulp travel, one finds that the slime is washed away and sand remains, which is most unsuitable for building up the wall.

When laying out a slime dam on sloping ground, the first cost of throwing up a retaining wall may be two or three hundred pounds, and after a few days run the slime is level with the top of the wall, and not until the wall has attained a height, say, of 30 ft. or more, is there any large area for conserving slime; at the same time the wall will have probably to be stepped in at an angle, say, from 35° to 40°, with the horizontal to conform with the dip of the ground and its surroundings. Where the area available is level, the strain on the outside walls is not great, as slime contracts in drying, and so takes the bursting pressure from the walls; where the area is sloping ground, the pressure must be greater on the base wall, and so call for special precautions.

The method for dewatering a slimes dam can be settled at once where the area is level. Where the area is on sloping ground it is necessary to drive the water away from the base walls, inclining to one side near to the inner wall of the slime channel, and so on, until the dip of the ground is overcome when a suitable dewatering launder can be put in conforming to the requirements—that is moisture settled out plus rain water in the wet season.

The paper by Messrs. Thomas and Osterloh opens out a big field for discussion, and takes in one subject that has been missing for many years in our *Journal*.

Mr. A. King *(Member)*: To those members whose duties include the supervision of slime residue disposal this paper will be found extremely helpful. To some the conditions described may appear almost ideal—daylight discharging, no sand dump encroaching on to the dams which are of large area and, when well started, sufficient fall for returning solution to the cyanide plant without the aid of pump and pipe line.

For some eighteen months the slime dams at the Knights Deep, Ltd., have been built up in a similar method to that described by the authors, viz. With an inside wall forming a fairly wide channel all round, and from his experience with this method the writer is able to confirm the following advantages indicated in the paper: (1) the heavier and more suitable portion of the slime becomes available for building all walls, (2) the inside of the dam being 1 ft. to 2 ft. lower than the outside channel, the latter, having to dry out periodically, takes the place of a thick heavy wall capable of holding back with comparative safety a large volume of storm water until it can be drained off, (3) discharging at night time (from plants which have no vat capacity to spare) may be carried out.

Some twelve months ago, owing to lack of fall and the contour of the ground, it became necessary to abandon one of the two dams which had been in use on the above property, and to give sufficient area the other dam had to be used in conjunction with an old dam against the lower end of which the newer dam had been built. The latter had reached almost the same height as the old dam, and by the above method of building a channel all round it was found practicable to run the whole as one dam, there being no conveniently available ground on which to build a new dam. In operating this dam the slime is made to flow in one of the two directions as becomes necessary to allow any part of the outside channel to dry sufficiently for building with shovels, and is led into the inside of the dam at any desired point. The height of this dam at the lower end is approximately 100 ft. at present, the circumference is about 1,500 yards, and from 45,000 to 50,000 tons dry slime are discharged per month—roughly, a charge of 400 tons every six hours. The writer does not wish to convey that one dam is sufficient, but only desires to point out that when necessary all slime residue from the cyanide plant can be disposed of for a considerable period and without inconvenience in one dam, by using the method described by the authors.

The following results of samples taken for moisture determination may be of interest, as indicating the moisture retaining capacity of ore slime.

A.—Samples were taken from a cutting through a dam at the Robinson Deep, on which no slime had been discharged for about ten years. The cutting was made about six years ago, and the samples were taken from a hole excavated horizontally, 5 ft. from the base and 17 ft. from the top. The first sample was taken 1 in. behind the crusty surface, and contained 5·9% moisture; other samples were taken 1 ft., 2 ft. and 4 ft. in, and contained 6·3%, 11·1% and 24·0% moisture respectively.

B.—Samples taken from a slime dam wall at the Robinson Deep, at distances of one inch, 1 ft., 2 ft., 3 ft., and 4 ft. from the outside contained 21·3%, 23·0%, 24·6%, 22·7%, and 27·7% moisture respectively.

C. and D.—The following were the results obtained in two series of samples taken from the walls of the slime dam in use at Knights Deep. The samples were taken at a distance of 4 ft. from the outside and at intervals of approximately 8 ft. vertically:—

	C.	D.
	per cent.	per cent.
8 ft from ground level	28·8	25·7
16 ,, ,,	28·4	22·8
24 ,, ,,	26·3	16·7
32 ,, ,,	24·6	20·8
40 ,, ,,	23·0	22·4
48 ,, ,,	23·3	18·9
56 ,, ,,	18·6	17·5
64 ,, ,,	20·3	17·3
72 ,, ,,	21·4	18·8
80 ,, ,,	20·3	21·9
88 ,, ,,	23·4	15·2
96 ,, ,,	21·2	24·5

These results would appear to indicate that the tendency of the toe of the dam to be thrust out by pressure from the inside should be guarded against by having a trench of heavy slime at the bottom of the walls, as mentioned by the authors, or preferably, if the dam is likely to attain any great height, by building narrow "subsidiary stepped dams" round the base of the main dam.*

Narrow dams should also be built round the outside walls of an old dam, when it is intended to bring the latter into use again at a later date. This was done with two old dams on the Knights Deep, and when the narrow dams had reached the level of the old dam, slime residue was discharged on to the latter without having to overcome the difficulties of stopping the considerable leakages which are bound to take place in re-starting an old dam.

Mr. H. Brazier *(Associate):* The thanks of reduction officials are due to Messrs. Thomas and Osterloh for bringing forward their interesting paper on the above subject.

With the rapidly increasing proportion of slime made on the Reef the satisfactory

---

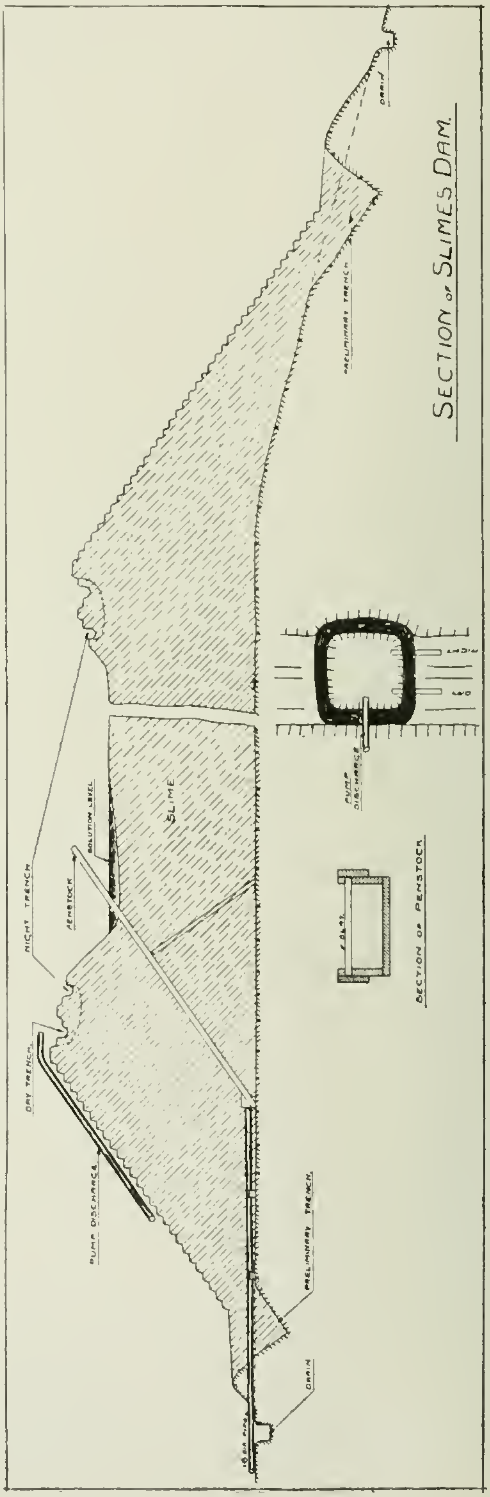
*See this *Journal*, October, 1915, p. 67, "Note on Building Slime Residue Dams," by Dr. W. A. Caldecott.

disposal of residues becomes more and more difficult. Like a great many other reduction men, I have experienced a fair share of these troubles, and the following remarks, whilst to some extent a criticism of their paper, show how some of the difficulties have been overcome.

The preliminary trench or channel advocated by the authors serves its purpose in constructing a new slime dam just as effectively as an expensive retaining wall. The trench illustrated in their sketch "keys" the wall, but where the ground dips sharply, additional strength is gained by designing the trench so that its outer wall is at right angles to that of the dam wall, which it has to support. (See sketch.)

The secret of a successful slime dam appears to be firstly: to keep the walls in the best possible condition, *i.e.*, free from cracks by using the walls themselves as channels. Secondly—to so distribute the pulp that all water immediately gravitates to a given point; and finally—the catchment area of modern dams being large, to always be in a position to deal quickly and effectively with a flood of storm water.

The reliability of the penstock, or "L" shape launder, is of the utmost importance; and can, with advantage, be built on the solid ground instead of waiting for the first 2 ft. of slime as suggested. Also, instead of "L" shape, and a number of "L" shaped extensions, it will be found simpler to substitute an incline for a vertical launder, the angle of incline to coincide with the angle at which it is decided to build the dam wall. The incline portion should be supported from the ground by two substantial props. Extensions in suitable lengths become a simple matter, only one joint (butt and strap) being required, the overflow always being equidistant from the wall is a convenience in adjusting slats and the risk incurred by building horizontal launders on slime, which is apt to yield to the ever increasing pressure, avoided. The authors' method of holding slats in position by guides supported at intervals by "horizontal struts nailed in the launder" has been found weak in practice; the guides being liable to collapse, entailing the abandonment of a penstock which may have cost quite an appreciable amount to build, apart from a host of other troubles due to it being out of action when urgently required. This weakness has been overcome by cutting the slats to the overall width of the launder, and bolting an extra piece of timber on either side of the launder, form-



ing a groove for the slats, thus the whole side becomes a support, and resistance to the pressure equalised all round.

The channels for conveying the pulp being graded from the point of delivery by the discharge pump, the walls here are usually stronger than elsewhere on the dam and proximity to this point appears to be the best position for the penstock.

Just as too much sand is detrimental in building, due to "crumbling" in dry season, and rapid erosion in the wet, so the absence of sand means a "treacherous" wall. A fairly even distribution of sand along the channels can be obtained by carefully grading according to the consistency of the pulp, and the grade once established is easy to maintain.

As to the most suitable angle at which to build the dam walls, this appears to be governed by the contour of the ground and immediate surroundings, *vide* Government Regulations, and may vary from 30° to 50°.

The advice to discharge more slime during the day than at night cannot be acted upon where a Butters' plant is in operation, but if a double channel is made, and the inner one, which should be at a slightly lower level than the outer, retained for night discharges, trouble is rarely experienced.

Where springs are existent, a drain dug at the foot and a few feet away from the walls is of assistance in preventing slip, and in the wet season prevents accumulation of water against them.

Mr. Fraser Alexander *(Visitor):* I am honoured by your invitation to contribute and place before your Society my experience in connection with this subject.

There are certainly a few points worth nailing down as hard and fast principles on which slime dams and depositing sites should be laid out and run—such as sufficient room—which we may call the site, the system or method to be adopted, and the intelligent disposition of the whole scheme based on at least two-thirds of the probable life of a mine.

The authors, I note, place first in importance the elimination of water or moisture from the slime forming the retaining wall of the dam.

The site on which the slime is to be conserved is of paramount importance. Secondly, the area or size of the dams in their relation to the quantity, and thereafter the intelligent disposition of the solids, allowing at all times a complete system of drainage through penstocks of sufficient size to cope with any sudden downpour of rain or flow of water conserved on the dam for several reasons—may I explain that the term slime is the finer portion of the crushed rock from which the gold has been extracted, and comprises, roughly, 50% of the whole ore treated on these fields. The slime is water-borne as a cheap and efficient means of removing the residue from the treatment vats to the depositing site (or dams).

Like most refuse, it is a good thing to get rid of, and being water-borne, let it go anyhow for choice, hence you will find quite a large number of dams with their retaining walls built on swampy ground or very deep marshy valleys, where it becomes almost impossible to retain the weight of solid slime when the dam is 30 ft. or 40 ft. high and possibly the weight of a slowly growing sand dump on the top of this sloppy foundation might explain the collapse of the dam referred to by Mr. H. A. White along the Main Reef Road.

The selection of a site is, therefore, of much importance, and this site should be chosen with care and forethought, taking into consideration the life of the mine and allowing for a growth of not more than 6 in. of solid slime per month on the retaining walls of the dams. I will assume that a ton of solid slime will occupy 25 cub. ft. of space in the dam, and allow for conserving 50,000 tons of slime per month. This means that you have to handle as much water as slime, or 100,000 tons in all, as one of water to one of slime is about the ratio at which the pulp will flow in its own channel given a grade of 0·8% fall. Now to build 6 in. per month you require a dam of 800 × 350 yards divided into two sections with two points of intake (for preference) and four penstocks (or outlets); if only one inlet, let it be near the centre, and for preference at the lowest side of the site where the dam wall is likely to be built highest.

The authors' approximate size, *i.e.*, 6,000 yards or 7,000 yards in circumference is certainly a most desirable quantity: *but*, is so large an area necessary?

I do not agree with the authors' design of penstock, as the horizontal launder is liable to rot or decay and crush under the weight of the slime built up thereon. The joining of wooden launders is a very unreliable proposition; a 9 in. or 10 in. pipe tarred on the outside is preferable, and the vertical section should lean to approximate the batter or slope of dam wall, say, 45°. By building the dam 3 ft. vertically and then stepping back 2 ft. the walls appear to stand the downpour of rain better than the plain surface. There are, of course, many methods of building up the outer walls of a slime dam, notably the construction of wooden launders round the whole circumference of the dam. These launders are carried on rough timber trestles and the slime is allowed to run from the launders at any point desired.

The chief points of objection to this method is, first, cost of launders, and thereafter, cracking, and consequent weakening of the points of contact with the woodwork and slime. I never favoured this system, but prefer to build the outer walls with shovels in the hands of well-trained natives (who become skilled in this work after about six months' training) and by building up 4 in. at a time over 3 ft. wide with a slope of 1 ft. in three (inwards) you insure the maximum area, on which a man can work with comparative ease, being compressed both by standing thereon and beating or compressing the slime when depositing the 3 ft. on the wall, the practical result being that you puddle or harden about 6 ft. By building the outer walls only 4 in. at a time, with a batter of 1 ft. in 3 ft. you minimise the possibility of shrinkage cracks developing right through the outer wall, particularly so if the walls are kept, say, 6 in. above the inner or control wall.

This system of running the slime to any given point around the periphery of the dam, confined between two walls about a foot above the level of the interior of the dam, I will term the irrigation system, and was first carried out with complete success on the Ferreira Deep G.M. Co. in 1904-5 by myself.

Where the dams are located on reasonably solid ground with a toe or key excavated, as described by the authors, I have no doubt the walls can be carried up to a height of 60 ft. with perfect safety if constructed on the irrigation system and built up at a rate of not more than 6 ft. per annum. The slime from our banket ores does not readily solidify, probably due to the absence of oxygen which is absorbed by the decomposing pyrites present.

After 20 years, where the slime was deposited 18 ft. deep on a well drained site the central portion throughout the dam, a few feet below the surface would not bear the weight of a man—I mention this to show that stepping back on the surface of a dam, say, 20 ft. deep and then going up another 20 ft. is fraught with some danger where the ultimate aim is, say, 50 ft. high.

In conclusion, I would like to endorse Mr. H. A. White's remarks, when proposing a vote of thanks, that the disposal of waste products might well be considered when the shaft is being sunk.

Where the site is on the gradual sloping side of a property, calculate the required area on the basis of 6 in. per month, and start the dam as far away from the works as your directors will allow; then build up and gradually control the return water at your own pleasure.

The slipping of one of these slime dams into a natural water-way is obviously a serious matter, and may cause immense damage in the rainy season, in many ways, and not the least of these many ways is the silting up of storage water dams.

Mr. E. M. Weston *(Member of Council)*: The authors give a most useful summary of the best Rand practice in constructing slime dams. We must remember that it is a question of safely dealing with enormous daily tonnages at a minimum of expense. It is obvious that the outer wall is exposed to stresses acting in a similar way to that to which an ordinary dam containing water is exposed, and if the condition of saturation of the interior of the slimes dump is known, and the weight and coherence of the outer wall of dried material be ascertained, the matter might be dealt with mathematically. Most of the failures of outer walls I have seen appeared, however, to be due to the accidental saturation of the outer wall, which destroyed its coherence. The question arises, is there not some cheap method available of reinforcing this outer wall. Two possible ideas present themselves. The first is to use cheaply constructed grass mats. The second is to follow the Australian practice and reinforce the outer wall by brushwood laid with the leaves towards the inside of the dam. Trimmings from plantations are plentiful, and transport would be the only charge, in many cases, to be considered. Had the Witwatersrand mine dump been thus reinforced, I doubt if it would have failed. Mr. White's ideas on the subject generally are worthy of serious consideration in high quarters.

NOTES ON THE SUPPORT OF THE UNDERGROUND WORKINGS OF THE MINES OF THE RAND.

By Percy Cazalet *(Member)*.

SYSTEMATIC PACKING UNDERGROUND AT THE FERREIRA DEEP MINE.

By G. Hildick-Smith, B.Sc. *(President)*, and Paul Selby, B.Sc. *(Member)*.

(Printed in Journal, July, 1917

DISCUSSION.

Mr. E. M. Weston *(Member of Council)*: Some of the statements in Mr. Cazalet's paper are, to say the least of it, alarming when the future of the deep level mines of the Rand is considered. He predicts that in ten years' time, unless a radical change is made in mining methods, all mines on the Central Rand will be in grave danger. At that time only the third row will be working, and we know that they have already been heavily drawn upon by the old system, and it certainly remains a question whether, if Mr Cazalet's prediction is well founded, it will be possible to save them. There are, however, certain factors in the question to which, I think, Mr. Cazalet has not given due weight. They are not altogether pleasing factors, but they tend greatly to modify his conclusions. The country rock above the outcrops and the deep mines failed, firstly, because it was undermined over almost its whole area by wide stopes and it had its strength already weakened by the changes in flexure from 80% to 35%, dikes and faults destroyed its resisting power as a whole, and consequently whole blocks settled from the surface. Such conditions are not duplicated in the deep ground. It is a fact, explicable, either by the infiltration or placer theories of gold deposition, that the proportion of unpayable ground in depth has increased, and that in the deeper mines, instead of stoping 90% or more of the reefs, 30% or perhaps more, will be left as solid pillars, and the payable areas will be interspersed between them. It is obvious that the conditions of pressure and settlement must be very different in the two areas. Again, apparently the deepest mines will have to depend mainly on one reef, as the Main Reef apparently no longer underlies the Leader, but is separated by a width of quartzite, and thus cannot be stoped with the Leader and must, in most cases, be left. The South Reef shows signs of weakness, and generally only the Leader will be stoped to any great extent. This reduction in reef widths does not, perhaps, occur everywhere in depth. There are very large stopes, I believe, in the deepest mines of the Germiston area, and of course on the East Rand; but it is, I think, generally true. On the Far East Rand, payable areas are interspersed with areas of no value, and there is, of course, only one reef to stope. With a dip of only a few degrees, the settlement of the hanging occurs in a different manner. Nothing, however, that I have written must be taken as implying that the splendid method that has been evolved to meet terrible difficulties, by the author and others, may not be the most suitable in many cases in the mines mentioned. I do not, however, think that Mr. Cazalet can make out a case for the abandonment of shaft pillars in the flat mines of the Far East Rand; if protected by pillars of reasonable dimensions the shafts cannot possibly be effected by any settlement of stopes in such flat strata. In this practice we can safely follow the coal miners.

Would Mr. Cazalet advocate that all drives be kept under the reef in future in working with this method? I do not see how it is possible to maintain the drive pillars shown in the plans of working under this system at the Ferreira Deep.

The President: There are still several papers on which there has been very little discussion. It would be very interesting to have some discussion on them, and I hope members will do their best, if they cannot contribute to the discussion themselves, to persuade their friends to do something in that direction. Discussion is very valuable, often more so than the original paper. It is essential that we do get some discussion, if possible.

The meeting then terminated.

Proceedings at a Special Joint Meeting, September 29, 1917.

A Special Joint Meeting of members of the Chemical, Metallurgical and Mining Society and the South African Institute of Electrical Engineers was held in the Lecture Theatre of the South African School of Mines and Technology, on Saturday, the 29th September, 1917, at 8 p.m.

There were present:—Mr. G. Hildick-Smith (President), Profs. G. H. Stanley and J. A. Wilkinson, Messrs. J. E. Thomas, R. W. Bennett, W. M. Coulter, A. Fraser, A. King, W. A. Ledingham, H. H. Morrell, J. A. Taylor, A. Thomas, D. J. Thomas, and T. P. Waites (Members), G. J. V. Clarence, E. G. Harding, T. L. Thorne, and J. A. Woodburn (Associates and Student), together with a large number of Members of the S.A. Institute of Electrical Engineers and visitors.

Mr. W. H. Perrow (President, S.A. Institute of Electrical Engineers): I have much pleasure in proposing that Mr. Hildick-Smith preside over this meeting.

Mr. W. Elsdon Dew (Past-President, S.A. Inst. of Electrical Engineers): I beg to second that proposal.

Mr. G. Hildick-Smith (President, Chem., Met. and Mining Society): Mr. Perrow and gentlemen, as you know, this is a joint meeting of the Chemical, Metallurgical and Mining Society and the S.A. Inst. of Electrical Engineers, at which it has been arranged to hear papers read by Professors Stanley and Buchanan on "Electric Furnace Manufacture of Shoes and Dies on the Witwatersrand," and "Electrical Steel Melting Plant," respectively, describing what has been going on now for some time at the Robinson Gold Mine.

This beginning of an industry is, I believe, the outcome of suggestions from the Chemical, Metallurgical and Mining Society, and emanating originally from Dr. Caldecott, and, of course, the work could not have been done without the co-operation of the electrical engineers. We shall now hear what has been done, and, I am sure it will be agreed that excellent results have been obtained.

I will now ask Prof. Stanley to read his paper.

ELECTRIC FURNACE MANUFACTURE OF SHOES AND DIES ON THE WITWATERSRAND.

By Geo. H. Stanley, A.R.S.M., F.I.C., M.I.M.M. (Past-President).

Inception of the Scheme.—As one result of the war and consequent restriction of imports, the mining industry has found it to be imperative to utilise to the fullest extent all local resources in plant and material to supply its urgent necessities. Among the latter, obviously, stamp battery shoes and dies occupy a prominent place, a regular supply to the extent of about 7,500 tons annually being essential to the conduct of gold milling. Moreover, the Home Government requested South Africa, in common with the other Dominions, to make all possible metal manufactures locally and so lighten the task of the Home factories by releasing both metal and men for war purposes. Therefore, in order to consider the possibility of the manufacture of shoes and dies locally, a committee was appointed in February, 1916, at the instance of this Society,* consisting of the following representatives of the Technical Societies of the Rand: Dr W. A. Caldecott and the author (the Chemical, Metallurgical and Mining Society of South Africa), Prof. W. Buchanan and Mr. Bernard Price (the S.A. Institute of Electrical Engineers), and Mr. A. C. Holtby (S.A. Institution of Engineers). This committee reported that it was of opinion that such manufacture was possible by utilising existing accumulations of scrap shoes and dies, and strongly recommended that it be undertaken at once in view of increasing shortage and rapid rise in price. The methods considered by the committee and the reasons for the selection made will perhaps be best stated by quoting from the report, as follows:

"Method of Production—Type of Furnace and Plant.

There are two methods available:

(*a*) Forging large scrap shoes to form dies, which comes to an end automatically and quickly by shortage of suitable material.

(*b*) Melting and casting, with or without subsequent annealing and (or) forging.

---

* *Chemical, Metallurgical and Mining Society of South Africa*

For (*b*) the methods available appear to be:—

1. Melting in crucibles—coke or gas fired.
2. Melting in open-hearth gas fired furnaces.
3. Melting in electric arc furnaces.
4. Melting in electric induction furnaces.

With regard to these the following observations may be offered."

"(*b*.1.) *Melting in Crucibles—Coke or Gas Fired.* — While it is undoubtedly possible to melt steel here in this way, it can only be done in small quantities (crucibles holding 60 lb. to 80 lb.) and at high cost, since about three tons of coke are required per ton of steel; the crucibles are very expensive, will only last two or three meltings, and much labour is required. Further, the scrap used must be very good class stuff and carefully selected, and old shoes and dies would be inconvenient to deal with, requiring cutting up. For these reasons this does not seem to be a feasible method for the purpose in view, although the first cost is comparatively low. By the adoption of a regenerative gas fired crucible furnace, the working costs are materially lowered, since a fuel consumption of 25 cwt. of coal might be assumed and pots last longer, but first cost is largely increased and other objections remain."

"(*b*.2.) *Melting in Open-Hearth Gas Fired Furnaces.*—This does not lend itself to installation on the suggested small scale, a furnace of about four or five tons capacity would be the minimum commercial size, and this would probably produce the whole requirement at reasonable cost. The first cost would, however, be relatively large, the oversea pre-war cost of iron work and other material being about £4,000—foundation, freight, duty and erection of course extra. It would take a long time to instal, and probably necessitate considerable importations and consequent long delay. While not expressing the opinion that such a furnace would be unsuitable under normal conditions, in view of the special circumstances and requirements set forth previously, it may be considered as not being advisable at the present time."

"(*b*.3.) *Melting in Electric Arc Furnaces.*—There is no doubt but that with an electricity supply at 50 periods, and particularly three or two-phase, available, the most suitable type of furnace is the "arc" type. An arc furnace would probably produce a suitable product at reasonable cost, with the additional advantage of being able, at a future period, to utilize any kind of scrap iron or steel, and turn out any required grade of steel for various purposes, apart from shoes and dies. The immediate disadvantage is that the current available is not immediately suitable, and expensive special electrical arrangements would be necessary; furthermore, electrodes at least would have to be imported and are expensive—say £50 a ton, landed, for graphite electrodes, and the consumption would be at least 5 lb. or 6 lb. per ton of steel, so that, while at some future time this would probably prove to be a very successful type, at present it appears to be unsuitable."

"(*b*.4.) *Melting in Electric Induction Furnaces.*—An electric furnace of the induction type, similar to the Kjellin, appears to most nearly meet the immediate requirements. It appears to be practicable to construct it locally from existing material and of the required capacity. The Victoria Falls and Transvaal Power Co. can supply current suitable, with some modification, for a small furnace, and requiring comparatively inexpensive electrical arrangements. Alternatively, suitable generators, to be motor driven, are available. The Victoria Falls Power Co. will probably be prepared to assist in various ways in connection with the electrical arrangements. This type of furnace does not, however, lend itself to working up miscellaneous scrap in the same way as an arc (or combination induction-resistance) furnace, but this is not contemplated at present. The patents involved appear to be out of date. This type has an advantage in not requiring electrodes, and since all material needed is available, its construction could be done quickly—probably 6 to 8 weeks. Unfortunately it is essentially one for a low frequency current, for the power factor is very low at, say, 50 periods unless the thickness of the furnace walls is reduced to such an extent as to reduce the efficiency by large radiation. This prohibits its construction of a large size if the 50 period current has to be used. Again, the best shape of furnace section is a deep, narrow channel, which is not very suitable for melting the scrap stamp ends. If, however, the generators previously referred to are utilized (which will necessitate moving them from their present site), 10-15 period current will be obtained, and the problem of furnace design becomes more easy. This would, therefore, appear the better course to adopt."

"A complete plant, beside the melting furnace and electrical arrangements, would include the following:—

Appliances for breaking and cutting up scrap.
Appliances for handling scrap.
Moulds.
Drying stove.
Annealing furnace.
Reheating furnace.
Steam hammer or hydraulic press
Site.
Building.
Foundations.

The exact schedule will depend on whether casting direct or forging to shape is adopted. The simplest method would apparently be to cast to the required shape in a mould of sand or metal. Steel casting is, however, a very specialised art, and on account of blow-holes, piping, and "ingotism," the product, though probably satisfactory for dies, might not answer for shoes. It would be advisable to make trials in this way, and annealing the castings would improve them if necessary. By forging, a very satisfactory product should be made, and in this case billets might be cast in metal moulds and then forged, necessitating at least the employment of a large steam hammer and re-heating furnace. Assuming that certain items can be obtained on loan, the cost of installation at an existing plant should not exceed £5,000."

"QUANTITY TO BE PRODUCED AND CAPACITY OF FURNACE AND PLANT.

The object from the first would be to produce in commercial quantities, while at the same time, in view of lack of previous experience, keeping capital expenditure as low as possible. The plant must be considered, to some extent, as of an experimental nature, but at the same time ought not to operate at a loss. It appears probable that a furnace of about one ton capacity would be suitable. If this poured a "heat" of two-thirds of its contents only three times per day, two tons of steel would be obtained, equivalent to, say, 12 to 24 shoes and dies, depending on the individual weight. This is roughly 10 per cent. of the total requirement (say 20 tons per day), and very probably will be considerably increased, possibly even doubled, by quicker working. This, at any rate, would put beyond question the suitability of the product, and enable working costs to be more nearly ascertained, so demonstrating the feasibility or otherwise of the proposal."

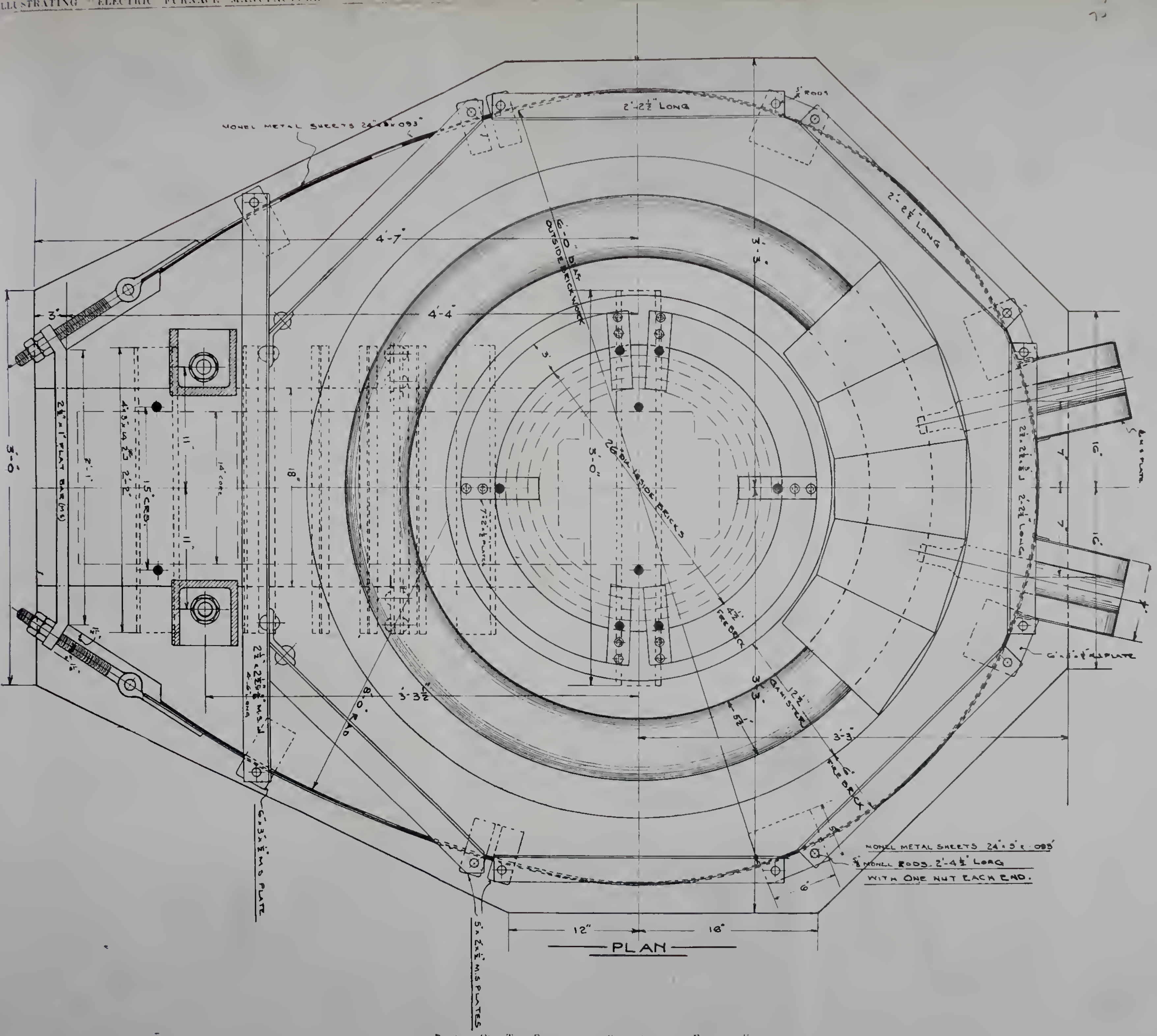
The committee further recommended that the plant should be installed in or close to the mechanical workshops of an existing mine, due regard being had to the electric power supply available; and that the Mining Houses should be asked to collaborate, through the Chamber of Mines, in the experiment. As a result the recommendations were adopted by the Chamber of Mines in March, and a shoes and dies branch of the Witwatersrand Co-operative Smelting Works, Ltd., was established, with a Committee of Management consisting of the members of the original committee, with the addition of Messrs. Lavenstein and Greener, of the Union Steel Corporation, Vereeniging, and Mr. W. Elsdon Dew; Prof. Buchanan and the author being appointed joint supervisors.

Material Available.—With regard to the material available, there is on every mine an accumulation of worn and scrapped shoes and dies amounting probably, in the aggregate, to several thousands of tons, and on the average, about fifteen per cent. of the new weight of shoes and dies is understood to be ultimately discarded as scrap. Much of this has been utilised for such purposes as flooring, but is mostly recoverable if necessary. There is consequently many months' supply for the furnace installed, but it is also possible to utilise other scrap of similar composition and suitable shape, difference in composition being rectified by suitable additions.

Analyses of imported shoes and dies are given hereunder:—

	A. Koppel	Orenstein-Koppel	Orenstein-Koppel	Orenstein Koppel	Fraser & Chalmers	Cammell-Laird	J. J. Colver	J. J. Colver	Sanderson Newbould	
Carbon	·915	·815	·818	·772	·865	·930	·930	·760	·79	·96
Silicon	·250	·267	·241	[illegible]	·225	·151	[illegible]	·223	·21	·17
Manganese	·633	·441	·385	·792	[illegible]	·672	·516	·504	·59	·61
Phosphorus	·028	[illegible]	·014	·060	·028	·053	·027	·016	·014	·010
Sulphur	·060	·055	·035	·056	·060	·070	·038	·049	·037	·021
	die	die	shoe	shoe	die	die	die	shoe	shoe	die

ILLUSTRATING "ELECTRIC FURNACE MANUFACTURE OF SHOES AND DIES ON THE WITWATERSRAND," BY PROF. G. H. STANLEY



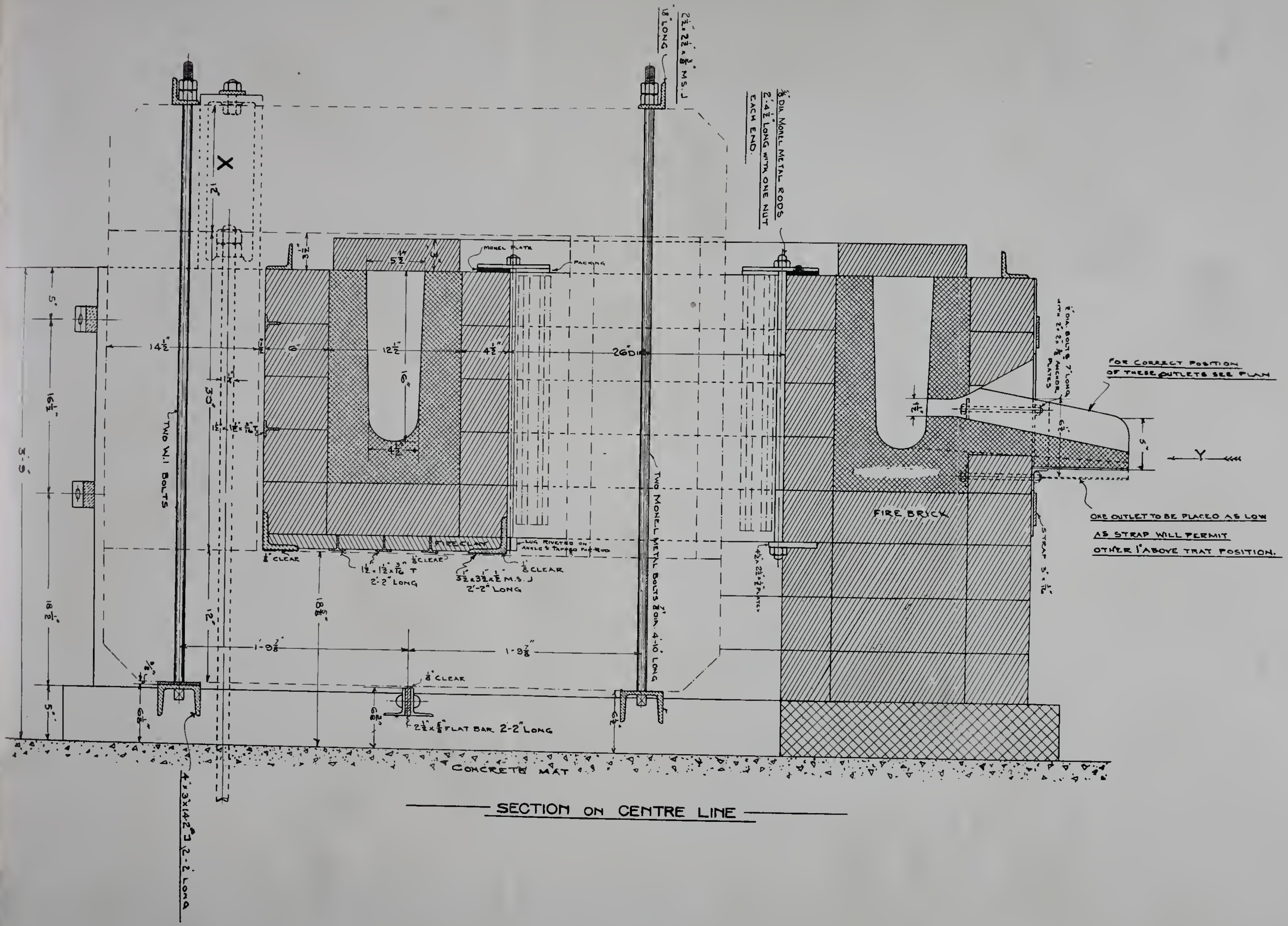
Plan of One Ton Experimental Steel Smelting Electric Furnace

period curr
problem of
easy. This
better cour
"A comp
furnace an
include the
Applianc
scrap.
Applianc
Moulds.
Drying s
Annealin
Reheatin
Steam h
Site.
Building
Foundati
The ex
whether c
is adopted
apparently
in a mould
is, howeve
account of
ism," the
factory for
It would b
way, and
improve t
a very sati
and in th
metal mo
ing at le
steam ha
Assuming
on loan, t
ing plant
"QUANTI

The ob
produce i
the same
experienc
low as p
sidered, t
mental m
not to op
able that
city woul

Carbon
Silicon
Manganes
Phosphor
Sulphur

ILLUSTRATING "ELECTRIC FURNACE MANUFACTURE OF SHOES AND DIES ON THE WITWATERSRAND," BY PROF. G. H. STANLEY.


X
Y
2½" × 2½" × ⅜" M.S. ∟ 18" LONG
⅝" DIA. MONEL METAL RODS 2'-4½" LONG WITH ONE NUT EACH END.
MONEL PLATE
PACKING
TWO W.I. BOLTS
TWO MONEL METAL BOLTS ⅞" DIA. 4'-10" LONG
4½" × 2½" × ½" PLATES
FIRE BRICK
FIRECLAY
LUG RIVETED ON ANGLE & TAPPED FOR ROD
⅛" CLEAR
1½" × 1½" × 3/16" T 2'-2" LONG
3½" × 3½" × ½" M.S. ∟ 2'-2" LONG
2½" × ⅝" FLAT BAR 2'-2" LONG
4" × 3" × 14.2# ∟ 2'-2" LONG
¾" DIA. BOLTS 7" LONG WITH 2" × 2" × ⅜" ANCHOR PLATES
STRAP 3" × 1/16"
FOR CORRECT POSITION OF THESE OUTLETS SEE PLAN
ONE OUTLET TO BE PLACED AS LOW AS STRAP WILL PERMIT OTHER 1" ABOVE THAT POSITION.
CONCRETE MAT
14½"
6"
12½"
4½"
26" DIA.
5¼"
3½"
16"
30"
12"
3'-9"
5"
16½"
18½"
18⅝"
6½"
1'-9⅞"
5"
SECTION ON CENTRE LINE

Section of One Ton Experimental Steel Smelting Electric Furnace.

period cur
problem of
easy. Th
better cour

"A com
furnace an
include the
Applianc
scrap.
Applianc
Moulds.
Drying s
Annealir
Reheatn
Steam l
Site.
Building
Foundat

The ex
whether e
is adopted
apparently
in a moulc
is, howeve
account of
ism," the
factory for
It would l
way, and
improve t
a very sat
and in th
metal mo
ing at le
steam h
Assuming
on loan, t
ing plant
"QUANTI
(

The ol
produce i
the same
experience
low as p
sidered, t
mental m
not to o
able that
city wou

Carbon
Silicon
Manganes
Phosphor
Sulphur

There is little difficulty in obtaining metal of this composition from selected scrap in the furnace employed, merely melting with little or no refining being involved, so that the scheme is practically independent of any imported material. Manganese is available in the form of manganese steel scrap, silicon and carbon in selected cast iron scrap and pig, carbon by gas retort carbon and charcoal, and of aluminium there is sufficient to last a considerable time.

Installation of the Plant.—A site and building was secured on the property of the Robinson G.M. Co., and work commenced on the site in the middle of May. Owing to the exceptional conditions obtaining, many vexatious delays occurred through shortage both of men and material; nevertheless, current was switched on to the furnace on September 3rd, nothing but locally available material having been used

The electrical arrangements were particularly under the charge of Prof. Buchanan, whose paper deals with that subject in detail, but it may be mentioned here that the electrical supply is obtained from the Victoria Falls and Transvaal Power Co., Ltd., at 2,000 volts, 3 phase, 50 cycles, by means of an underground cable from the nearest transformer house, about 300 yards distant. To supply current to the furnace a rotary transformer set was installed, consisting of a motor coupled to two generators and running at 250 r.p.m., all being adapted from other purposes by considerable alteration and rewinding, in order to give single phase current up to 600 amp. at the low frequency required,* about 12 cycles. The efficiency of the conversion is between 60 and 70%, which is all that could be expected under the circumstances, *i.e.*, old plant remodelled, and the power consumption, at the furnace, about 800 to 900 K.W.H per ton of steel melted. In the best month, July, it was 775 K.W.H.

The furnace itself was constructed as shown in the plate, with some slight modifications; the cores and yokes being built up of old transformer iron, and the primary winding, consisting of copper cable insulated with asbestos tape (each turn of cable being out of contact with the rest) being placed in a 3 in. coil space between the core and inner walls of the furnace. Between the inner wall and the coil itself, a cylindrical shield of asbestos sheet was placed with the idea of protecting the coil in case of the steel breaking through the wall.

Instead of elaborate water-cooling arrangements, air circulation alone is depended on for cooling the coil, a ventilating cowl of asbestos millboard—not shown in the drawing—being placed over the centre and connected to a chimney passing through the roof. At first a compressed air jet was used to increase the air velocity, but seemed to have no appreciable effect on cooling and was therefore discarded. This arrangement effects a very considerable simplification of design, and does not seem to be attended with serious drawbacks.

The body of the furnace is built up of special radial and rebated lumps made at Vereeniging (Fig. 1.) tied over all with steel hoops, terminating in screwed ends passing through yokes, so that tightening or loosening could be effected. Any further iron or steel work being very undesirable from the electro-magnetic point of view, the plates between these and the brickwork were of "monel metal"—another feature believed to be novel—in fact this alloy is used, replacing iron or steel, wherever desirable and possible in this furnace. To keep the power factor as high as possible, the interior wall was made 8 in. thick (plus, of course, the thickness of the lining), while the outer brickwork has a thickness of 9 in., in each case laid in fireclay. The cover bricks are of radial shape, 2 in. thick, and to prevent breaking or cracking are clamped as shown (Fig. II.) by means of monel metal rod flattened and bent over at the ends, and with screws put through so that they may be tightened up. A strip between them serves for lifting when required

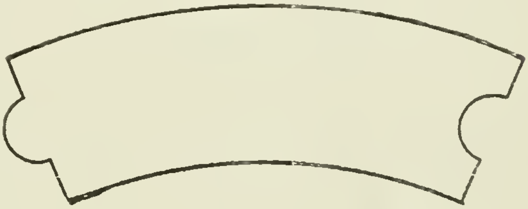


Fig. I.

In the annular trough formed between the inner and outer walls the working lining of the hearth is placed, and one of the initial difficulties was the selection of a suitable material for this lining. Knowing that reasonably pure magnesite occurred in the country, it was originally intended to construct the lining of calcined magnesite.

---

*See Stansfield. "Electric Furnaces."

but owing to the difficulty of satisfactorily calcining this material* the first lining was made by ramming "ganister," prepared by grinding together pure quartz with a small amount of fireclay, round a sectional wooden template, moved from place to place round the furnace till the lining was complete. Distance was kept with regard to the centre by means of a radius rod.

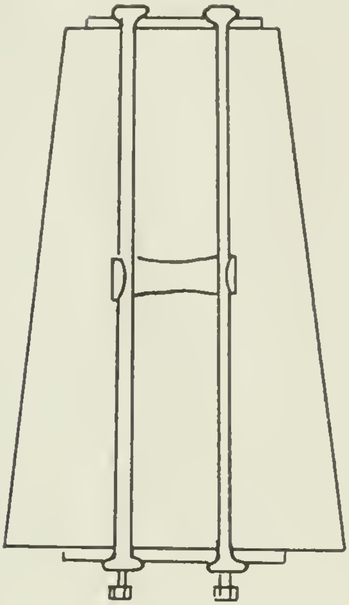


Fig. 11.

Operation of the Plant.—After removing the template, which left an annular trough 16 in. deep by 5½ in. wide, the lining was allowed to dry naturally over night and then warmed up by a fire bucket inside the central core space, and finally by burning wood in the hearth. Then, in order to further heat and start the furnace, coils of discarded wire haulage rope (again a novelty)—were placed in the hearth, the iron yoke fitted into place and current switched on. However, as the temperature rose, the expansion of the ganister caused it to crack in several places and strip away from the brick of the inner wall. Attempts to repair gave no promise of success, so that the attempt was abandoned. Moreover, the wire rope became badly oxidized, particularly by the tap hole, which had not been closed, causing it eventually to break circuit. All the inner wall lining was therefore taken out and replaced by tar-chromite mixture, rammed by hot iron rammers, as used with success by Mr. Greener at Vereeniging in the hearth of the steel furnaces, and a fresh start made with wire rope as before, but with a reducing atmosphere maintained by burning wood in the hearth. The temperature was raised very gradually for nearly three days till the rope began to melt, but with the unexpected result that since melting started at one point only, the melted metal at once dropped to the bottom of the hearth and broke circuit. Attempts to bridge the break by driving in iron bars and adding turnings, etc., were only temporarily successful, and finally fluid cast iron was obtained from the adjacent foundry of the Robinson Co. and poured into the furnace. This restored conductivity, but some of it solidified on top of the wire rope coil, hiding from view the hearth bottom which, as subsequently appeared, contained a small quantity of fluid metal, while the top solid ring, separated from it, was only red hot and heated by radiation from it. In the result, the temperature of the liquid metal was so increased that the inner chromite lining was melted through and the metal escaped on the floor, the foreman in charge at the time, who had had considerable steel melting experience, saying he had never before seen anything so hot!

The corrosion had been considerably assisted by chemical action by the carbon, etc., in the iron reacting with the lining so that the escaping metal was rich in chromium; it seems possible that this idea might be developed as a method for the production of chrome alloys. Considerable damage was done to the coil and transformer iron, and while this was being repaired the opportunity was taken to obtain from the Vereeniging Brick and Tile Co. some of the magnesite bricks which they had prepared experimentally but did not consider good, and have them ground down to prepare a fresh liner. This was ultimately made up of a lining of chromite inside the brickwork, faced internally with about 2 in. of tar-magnesite mixture. The heating was started as before with wire rope and molten cast iron, and this time with success. As a result several successful casts were made, though with severe trouble in the management of the tap hole, which broke out several times between October 7th and 18th, the position being still further complicated by the moulders' strike which took place at that time.

---

* The calcining temperature should be at least as high as that to which it is to be subjected in use, since it shrinks further with each increase of temperature.

Ultimately the furnace was cooled down and the tap hole re-made entirely, but two days after re-starting the metal again broke through the inner wall, damaging the transformer more severely than on the previous occasion, and necessitating another long stoppage.

While the repairs were in progress, another difficulty was remedied by modifying the shape of the template to give a hearth 7½ in. × 13 in., and so facilitate the feeding of awkwardly shaped pieces of scrap, though doubtless at the cost of a certain loss of electrical efficiency. It may be mentioned that the slag adhering to the walls reduces the free space for feeding, so that the original width of 5 in. sometimes made feeding extremely difficult. The diameter was also slightly increased and certain holding down bolts, found to be unnecessary, were omitted, so that the present design is not quite as shown in the drawing. The template was also made continuous all round the hearth.

The new lining, except for about 4 in. of chromite underneath, was rammed entirely of the magnesite from Vereeniging—with tar—which, although known to be impure, was the only supply then available.

After starting up as before, on November 9th, the furnace worked relatively smoothly for over a week, and if the output was small, it was chiefly due to inexperience; as a matter of fact it only averaged about one cast per day of two or three each shoes and dies. However, the lining cracked and it was emptied to avoid risk of damaging the transformer.

During this time the position as regards magnesite had been under investigation, and it was found that nearly pure magnesite was obtainable from Kaapmuiden, the analyses of four samples showing:—

Silica (SiO_2)	1·0	1·05	0·45	2·5
Lime (CaO)	·08	·20	trace	·10

A consignment of this was, therefore, obtained and calcined at Vereeniging, but unfortunately, it could only be done at the same time, and using the same machinery and kilns as for silica bricks. Consequently considerable contamination occurred, and analyses of different consignments used for lining showed silica present from 9·7% to 11·0%. However, subsequent relinings were carried out with this material, at first using tar as a binder, but later employing a mixture of clay and boric acid, recommended by Prof. Arnold, of Sheffield University, in the proportion of 140 lb. clay, 20 lb. boric acid and 40 lb. of water to 2,040 lb. of magnesite; but it was found necessary to largely increase the amount of water.

Commencing with the employment of a magnesite lining, progress was rapid, and early this year operations became nearly normal. Early troubles were largely due to alternate heating and cooling of the lining due to labour troubles and other enforced stoppages mentioned, and as these have been eliminated or lessened the frequency of tapping and consequently the output has increased till for some time between 1,900 and 2,000 lb. of castings have been regularly obtained every eight hours, and now the period is being reduced to six hours. Apart from the material of the lining, the chief difficulty in the early stages was oxidation of the metal and consequent loss of carbon and manganese content, which besides softening it, made it much less fusible. This was due to the rust on the scrap, to scale formed during preheating, and partly also to admission of air to the furnace by defective covers. When, in the early stages, a heat lasted sometimes 24 hours or more, it is not surprising that on occasion all the carbon was lost, and dead soft iron was produced. This has been remedied by more rapid working, and by keeping a little charcoal on top of the metal in the furnace. Indeed, the charcoal is so marked in its effect in facilitating the working of the furnace that it is difficult to make the furnace hands (Cape coloured men) use it in sufficient moderation, and for a long time carbon in the steel was nearly always much too high, generally 1·1% to 1·3%. Even now it does not seem advisable to dispense with it entirely, though trials have been made, but by exercising proper care, carbon can be kept at about the desired figure, while by stopping formation of oxide the furnace walls are preserved to a considerable extent from corrosion and the life increased.

The chief furnace trouble met with at present is the formation of a "crust" of solid metal more or less completely covering the surface of the molten metal. It is not serious if noticed and dealt with in time, but if allowed to increase by building up and feeding more metal, entails much labour and risk of damage to the walls in detaching it. It does not seem of any assistance to try to make a slag, which indeed is difficult to keep fluid, but sometimes to clean the metal a little fluorspar has been added. Another difficulty, in a recent lining, arose from trying to incline it towards the tap hole. This reduced the cross section of steel too seriously at the other side, and caused several breakages of circuit, probably due to the "pinch" effect, after tapping; so that the tap hole had to be raised. However, having the hearth level leaves a ring of metal every time the furnace has to be completely tapped out for relining. In normal operation, lining and working proceed as follows:—

The old lining having been stripped out immediately it had cooled sufficiently (and after removing the top transformer yoke) the bottom is rammed into place with hot rammers, little by little, and then the template or "former" supported in position.

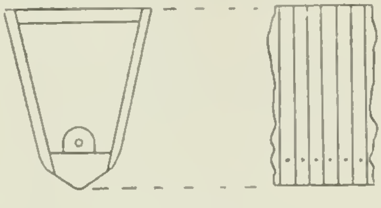


FIG. III

This is constructed as shown (Fig. III.), so that when the ramming is completed, by taking out the top pieces the sides can collapse to some extent, thus loosening and facilitating withdrawal. Lately the bottom has been made rather more V shaped, so as to keep a continuous ring with less weight of metal. The walls are then rammed in the same manner, and when complete, about 12 hours from the last tapping, the template is withdrawn, the walls completed with a course of flat radial bricks, the coil of rope inserted and the yoke replaced, this occupying about three hours more. Current is then switched on, and the furnace is ready for more foundry metal within 30 hours of the last cast. Three ladles, about 500 lb. in all, are then carried across from the foundry and poured in. Generally this solidifies, but in two or three hours is melted again and feeding of scrap commences.

The scrap has been heated to redness in the furnace attached to the drying stove, and is transferred by means of tongs to the electric furnace, feeding in several places through spaces left by removing a cover block. This is kept up for two or three hours more, about 2,000 lb. of scrap having been charged, after which the metal is left at rest to become hotter and ready for casting, no metal being ordinarily fed within one hour of tapping. At this stage the required amount of pig iron and manganese steel is added. Towards the end, most of the slag is skimmed off on the end of flat iron bars, and shortly afterwards the top tap hole is opened in the usual manner, by drilling out its centre, which has been plugged by a friable mixture of magnesite, coal dust and clay; the hole itself being lined with the same mixture as the furnace. When the flow of metal has practically ceased it is stopped by placing two or three suitable flat pieces of scrap against the tap hole inside the furnace. Any metal in the tap hole is removed while hot, and this removal is important, or a break-away may be caused subsequently, and the hole is then made up again. Thereafter charging goes on as before, but with scrap only, except for the additions at the end. The first two or three heats are cast into dies, on account of the high carbon, sulphur and phosphorus content due to the cast iron, leading to breakage of shanks if cast into shoes, thereafter three shoes and five or six dies, or latterly even eight shoes are made per cast.

Cracks and holes appear in due course in the lining, but so far it has not been found possible to patch them successfully. It is often stated in text-books that this is done, but enquiries have failed to elicit how; perhaps the discussion on this paper may bring out this point.

In order to save time in ramming, a pneumatic hammer tool was used recently, and apparently used too well. Nearly 50% increased weight of magnesite was rammed into the lining, and when this was heated up it expanded and cracked badly. This method is still in course of trial, but with a lighter blow, and seems likely to save considerable time, *e.g.*, the interval between the final cast of the old lining and first cast of the new is reduced to about 10 hours only.

Method of Pouring and Casting.—A tilting furnace would obviously have prevented much trouble with regard to the tap hole and tapping, and could doubtless have been made, but in view of the necessity of keeping initial outlay as small as possible the fixed form was decided upon. This usually necessitates the intervention of a ladle between the furnace and moulds, the metal being tapped into the ladle and poured thence into the moulds. Originally, therefore, a ladle and suitable handling gear was installed, the intention being to pour over the lip. However, owing largely perhaps to slow and inexperienced handling in the early stages a very large proportion of the steel melted partly solidified in the ladle, forming skulls which constituted so much waste, it being impossible with the available appliances even to break them up for remelting. In addition, the frequent relining required entailed much expense and delay. Hand ladles or "shanks" of smaller size were then substituted for a time, three being used in rotation at each cast. This arrangement reduced the loss to some extent, though it was still large, but there was still much lining to be done and, moreover, it was very awkward to operate in the somewhat confined space. Therefore, after some other trials the present method was arrived at.

As shown in the illustration (Fig. IV.), the tapping spout is somewhat lengthened, and has attached to its end a box of sheet steel provided with a bottom outlet through a fireclay nozzle, and forming a kind of forehearth. The spout and forehearth are lined as usual and, of course, patched and faced after every cast. The outlet can be closed by means of a fireclay plug, as usual in bottom teeming steel ladles: this plug being carried on a rod actuated by a lever in front, worked by hand. Directly underneath this, and at right angles to the spout is a line of rails on which a series of flat bogies carries the moulds, so that they can be moved in turn underneath the nozzle. When the furnace is tapped, the metal runs into the fore-hearth and from thence, after a few seconds, to the first mould by opening the outlet. When the mould is full, the plug is lowered to shut off the stream, and the next mould pulled into position, and so on. Two moulds are mounted on each bogie, and all of them are coupled together in a train pulled by a wire rope by means of a hand winch at the front end. This has considerably raised the daily output, and on several days over 3 tons of castings have been produced. Unexpected troubles do still occur, however, and sometimes occasion the loss of a heat, but with increasing experience this is becoming less frequent. It was soon ascertained that it was much easier and simpler to cast into the iron moulds (with sand tops), moreover, the operation requires less skill, and consequently nearly all the production has been made in this manner. But, while overcoming certain troubles, the use of iron moulds introduces others, *e.g.*, that when, in the case of shoes, the bottom of the mould, forming the shank of the shoe, is worn and rough: it tends to grip the solidified metal and prevent it shrinking normally thus leading sometimes to cracking at the butt. In use, this crack rapidly results in breakage. This may be overcome in future by moulding the shanks only in sand.

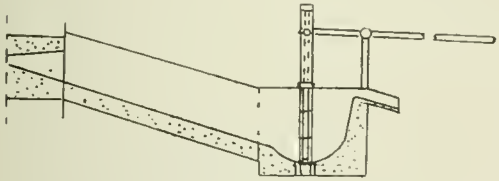


Fig. IV.

The arrangement is shown (Fig. V.), and it will be seen that there is very little moulding work required. To diminish this still further, trials have been made of tops formed of firebrick and even cast iron, but so far the balance of advantage appears to lie with those of sand. As soon as the mould is filled a little sand is thrown on top and a weight, usually an old shoe, placed on top of that, so that the metal solidifies under a slight pressure. Ultimately the feeder head is knocked off while still hot, and the casting is stripped. When cold enough, any fins due to the split moulds are trimmed off by hammers, and any irregularity where the head broke off dealt with in the same manner. To obtain sound castings a small amount of aluminium is placed in each mould before casting, this being found more effective than adding it in the furnace.

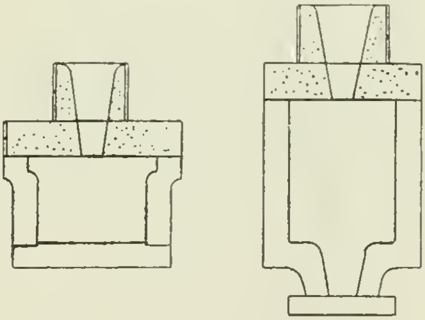


Fig. V.

Attempts were made to ascertain the

temperature of metal in the furnace before casting, both by means of a platinum rhodium thermo-couple and Féry radiation pyrometers, but neither method is satisfactory for continuous use: the former is rapidly destroyed, and the latter is difficult to use in spite of being mounted directly above the furnace, because the slag chills directly the cover is moved and the metal cools appreciably while slag is being skimmed. The eye, or the old "cutting the rod" test is still therefore depended upon.

The photo (Fig. VI.) shows some of the output, which is numbered on the decimal system, *i.e.*, 137·2 means No. 2 of cast 137.

Fig. VI.

In addition to the melting furnace itself, a coal-fired pre-heating furnace is installed in order to economise electrical power by heating the scrap to redness before it is charged into the electrical furnace, and so arranged that it also heats the drying stove. The arrangement is shown diagrammatically (Fig. VII.), and is also seen in the photo of the works' interior (Fig. VIII.).

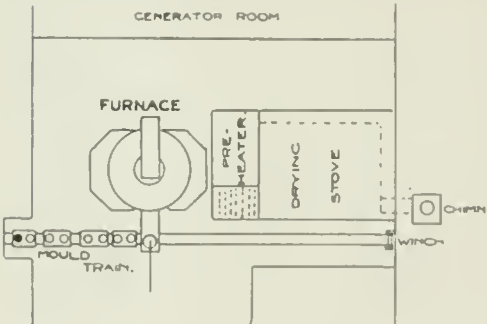


Fig. VII.

Fig. VIII.

The Product.—It must be confessed that at first the quality of the product was very irregular, a large proportion being honeycombed with blow-holes, and the carbon content varying very widely in different casts: with increasing experience this is being regularised, and a more uniform quality turned out.

Carbon is determined in every cast by the Eggertz colour test, a sample for the purpose being dipped out from the furnace on the end of a rod, and at intervals a complete analysis is made. Some of these are given below, and it will be seen that carbon is frequently rather high.

Carbon ..	·64	1·18	1·12	·774	1·07	1·13
Silicon	·11	·357	·149	·120	·186	·20
Manganese	·56	·600	·670	·352	·52	·24
Phosphorus	·054	·069	·013	·042	—	·021
Sulphur ..	·043	·059	·062	·057		·022
Chromium	·20	·14	·13			·022

Under the circumstances, it is scarcely surprising that the percentage of shank breakage among shoes has been somewhat high, but, of course, the reports so far received from the users mainly relate to the earlier product. Investigation showed that up to the end of April 58% of the breakages reported were due to honeycombed castings, and of the remaining 42%, 29% contained 1·1% or more carbon, and less than 6% had less than 1% carbon, so that too high carbon certainly seemed to predispose to breaking, and why this is so can readily be understood from the microphotographs.

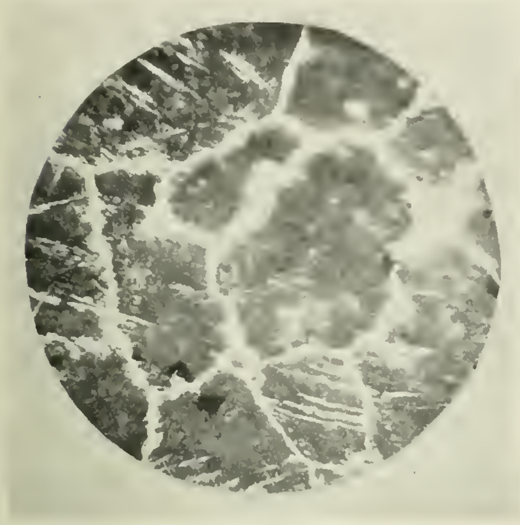


Fig. IX.

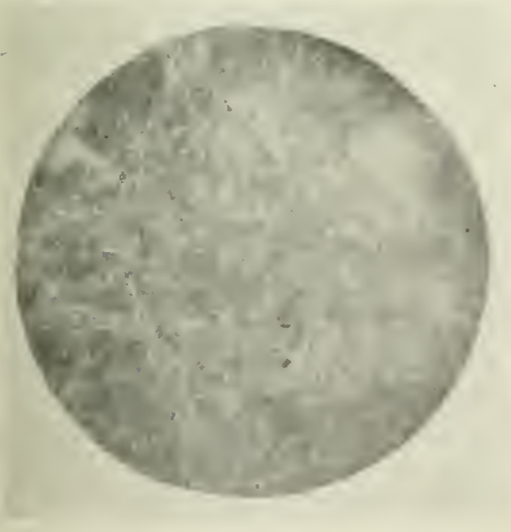


Fig. X.

Fig. IX. shows the section of a specimen containing too much carbon: the white network, consisting of cementite, is, although very hard, of course very brittle and apt to break under shock; while if the mass is constituted as shown in Fig. X., with about 0·9% carbon, no separate cementite is visible, and we have a strong homogeneous material. Even up to 1% the amount of free cementite is scarcely appreciable, and it is endeavoured therefore to keep the carbon below 1%. It was considered that annealing would probably improve the product, and in order to test this point part of the output was annealed and part not annealed and a record kept on the various mines supplied, of the behaviour of each one. The figures obtained indicated the same percentage of breakage among annealed as unannealed; but as the position was complicated in most cases by the excessive amount of carbon, more evidence is being accumulated before arriving at a conclusion. The temperature of annealing is, of course, important. Annealing for too long a time or at too high temperature may lead to cementite segregation, besides coarsening the structure by increasing crystal grain size, thereby having a detrimental effect, the change of structure being shown in Fig. XI. Apart from breaking, the life of shoes, though variable as might be expected from the variation in carbon content is generally 70% or 80 of that of the imported, but is considerably better as a rule in the lighter batteries than in the heavier. In a few cases the life has been even better than that of imported shoes.

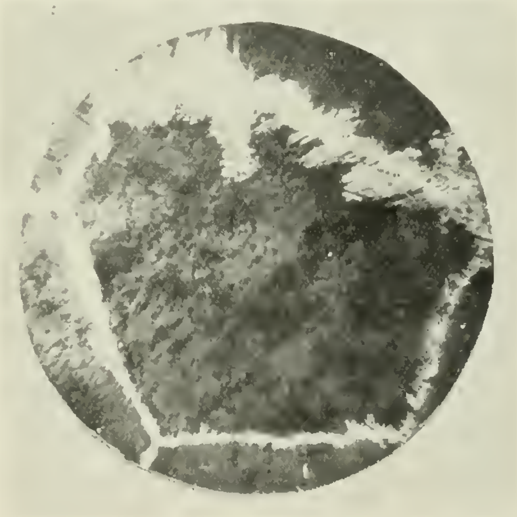


Fig. XI.

In the case of dies, the performance is considerably better than that of the shoes, lives of over 100 of that of the imported being frequent. If an appliance such as a large steam hammer or hydraulic press were available to compress the metal somewhat, it would without doubt be fully equal to the imported. At present, by the use of large headers in casting, it is endeavoured to keep the metal as sound as possible, but forging is impossible.

Operating Costs.—Working costs are somewhat high on account of the small scale of the operations, labour in particular being a very big item, in fact the same number of hands could probably turn out two or three times the present output with a larger furnace. Running, as it does, continually day and night, Sundays included, three eight-hour shifts are worked, and each of these requires an electrician in charge of the electrical plant and a furnaceman or moulder in charge of the furnace: for this latter it has been difficult to secure suitable white workmen, and coloured labour is employed therefore on some shifts under supervision of the electrician, consequently the number of white furnacemen on the pay roll varies between one and three. The actual furnace charging is done by "Cape boys," of whom 5 or 6 are employed in all, and about 15 natives are used in breaking up scrap and miscellaneous labour. All are under the charge of a works manager, so that the wages bill and supervision fees amount to about £400 per month. Electric power is the next big item, and amounts to close on £200 per month, and the cost of scrap at £1 per ton is third in order of magnitude.

The largest output so far was obtained in July, when 73 tons of castings were produced at a works cost of less than £14 per ton. In August nearly 69 tons was made, so it is quite safe to assume an average output of 60 tons per month. For this the costs would be approximately as follows:—

Scrap, 70 tons, @ £1	£70	0	0
Pig iron, 1½ tons, @ £20	30	0	0
Aluminium, 30 lb., @ 2/-	3	0	0
Magnesite (calcined), 2 tons, @ £18 ...	36	0	0
Miscellaneous stores	15	0	0
Repairs and renewals	15	0	0
Tools, etc.	5	0	0
Electric power	200	0	0
Cartage	30	0	0
Miscellaneous sundries	20	0	0
Salaries and wages and supervision fees	400	0	0
	£824	0	0

or nearly £14 per ton.

In concluding this account of the first commercial production of shoes and dies in the Transvaal, it may not be out of place to call attention to the exceptional opportunity which present conditions and prices present to make a serious commencement with the iron and steel industry which it has long been hoped will be established here.

Apart from the plant described, small as it is, there are only two other concerns turning out steel in any quantity and like it, both working only on scrap, and only one of these has melting furnaces, the other merely reheating and rolling. Both together, are quite inadequate to supply the local demand if importation from oversea became impossible. Further, the supply of suitable scrap, though large, is not unlimited, and in some directions there is an actual shortage of raw material already. So in this direction also the country is likely to be thrown on its own resources before long. From the point of view of the various iron foundries also, the position is much more serious and must give rise to careful consideration of the possibility of local production. Pig iron of first quality at present approximates in price to £25 per ton, while the pre-war price was about £9. At first sight even the latter figure seems attractive enough to encourage local production, but it must be remembered that the whole South African consumption—as pig—is comparatively small and a large output would only be disposable in the form of steel. Even as cast iron, however, the present requirement is enormously greater than before the war; much casting work is being done for the mines and other consumers which formerly was imported, and if only the iron were available at reasonable price, a large industry could be created in the manufacture of agricultural and other machinery and pipes. But a very much greater tonnage could be absorbed in the form of steel, and without attempting to cater for the whole of the very large and varied requirements now imported, comparatively simple products such as rails, shoes and dies, and rock drill steel could be made. In this connection the following figures are instructive.

In 1913, besides over £5,000,000 of manufactured goods of which iron and steel constitute a large proportion, raw or partly manufactured iron and steel totalled £916,275 (oversea value), and in the same year the mines of the Union alone consumed nearly £800,000 of such simple manufactures as those mentioned.

The Chairman: As these two papers are the complement of one another, I will now ask Prof. Buchanan to read his paper.

ELECTRIC STEEL-MELTING PLANT.*

By Prof. W. Buchanan, B.Sc., A.R.C.S., M.I.E.E. (Past-President, S.A. Institute of Electrical Engineers).

The paper just read by Professor Stanley gives a brief resumé of the steps taken to initiate the first electric steel furnace in this country, and also refers to some of the metallurgical difficulties that have had to be overcome before reaching the present condition of relatively successful operation.

This contribution is intended to supplement the former by giving a short description of the plant from the engineering standpoint, particular reference being made to certain special features of the design and construction, which are likely to be of particular interest to electrical engineers.

Before entering into the technical part of the subject, the author wishes to take this opportunity to acknowledge the great assistance received from the other members of the "Shoes and Dies" Committee, the former chairman, Mr. A. C. Holtby, the present chairman, Mr. W. Elsdon Dew, and Mr. Bernard Price, who were always willing to give useful advice upon engineering difficulties, and Professor G. H. Stanley, Dr. W. A. Caldecott, with Messrs. O. T. Greener and L. H. Lavenstein, who were equally keen to supply any desired information regarding the metallurgical materials or processes. Whatever measure of success has been attained is due mainly to the harmonious co-operation of the members of this committee.

Reference has been made to the advantages of the induction type of furnace for the mere melting of scrap having a suitable composition, the deciding factor in the present instance being that no electrodes are required with this type; since, however, it was found necessary to introduce a frequency converter, it is useful to compare the economic efficiency of the induction furnace including a frequency converter with that of the "arc" type plus electrodes.

A modern motor-generator of about 200 kw. capacity, converting three-phase 50 ~ supply into single-phase at low frequency would have a full load efficiency of at least 80 , and since it requires about 800 electrical units to melt one ton of steel, the loss by transformation is 200 units, which at, say, 0·6d. per unit amounts to 10s. per ton of castings. The consumption of graphite electrodes in furnaces of the Heroult type is at least 15 lbs. per ton of steel melted, while in the Stassano and Rennerfelt types, where the electrodes are not in contact with the metal or slag, it is about 10 lb. The price of graphite electrodes has very considerably advanced, and is now at least 1s. per lb., so that the cost is 15s. and 10s. per ton of steel respectively. The capital cost of induction furnace with converter would be about the same as that of the corresponding "arc" furnace, with its transformer, and electrode regulating gear.

The form of induction furnace adopted is usually called the "Kjellin" after the Swedish engineer who patented and constructed one of this type in the year 1900; it is, however, only fair to point out that an English patent in 1897, by a recent President of the Institute of Electrical Engineers (S. Z. de Ferranti), embodies exactly the same principles. Since this earlier furnace is not too well known, its construction is open to easy criticism, but it was up-to-date in so far as it was of the tilting type.

. . . .

Pinch effect.—One consideration which forms a limit to the minimum amount of metal left in the channel after each cast is the "pinch" effect, due to the attractive force existing between parallel conductors carrying like currents. The secondary conductor, being fluid, is liable to be broken by such pressure. In the event of the cross section not being absolutely uniform all round, the break occurs at the place of least section, where the current density is greatest. This phenomenon has been investigated by Dr. Hering, who gives for an open rectangular channel, whose depth is twice its width, the critical current density as $895\sqrt{\frac{G}{H}}$ in amperes per square inch, G

Editorial Note.—

The suggestion made by Mr. Dew on page 86 was adopted by the *S.A. Institute of Electrical Engineers*, but the Council of *The Chemical, Metallurgical and Mining Society* considered that the very specialised electrical character of Prof. Buchanan's paper, though rendering it of great value to electrical engineers, placed it, if published in full, somewhat outside the scope of the work of this Society. It is, therefore, considerably curtailed, but is published *in extenso* in the *Journal of the S.A. Institute of Electrical Engineers* for September.

being the spec. gravity of the molten metal, and H. the depth of channel in inches.

Example for a channel 8 in. × 4 in. and G = 7, critical CD is 835 amperes per square in. of original section, or a total of 26,800 amperes.

Besides this internal stress there is a bodily force acting on the molten conductor due to the repulsive effect from the unlike current of the primary, the magnitude of this force, with 30,000 amperes in conductors 14 in. apart, is 2·83 lb. per in. of circumference, with full channel of 72 sq. in. section, the same pressure would be produced, if the molten metal revolved at a speed of about 14 revolutions per minute. The elevation of the outer edge, when the metal is very fluid has no doubt given rise to the mistaken idea that the metal revolves bodily. . . . .

Pre-heating.—It has already been mentioned that normally the scrap steel is raised to a red heat in a coal-fired furnace before being fed into the electric furnace, and it will be obvious that where coal is reasonably cheap it must pay to pre-heat as much as possible, and thus increase the output for a given supply of electricity. The limit to such pre-heating being fixed by the excessive oxidation of the steel at high temperature when exposed to direct action of the heated gases in the reverberatory furnace, although this may be prevented to a great extent by keeping a smoky or reducing flame over the metal.

It is given in text books that about 360 k.w. hours of energy can heat and melt one ton 2,000 lbs. of steel at about 1,450° C., if it could be applied without loss. The specific heat cold is about 0·115, and it is usually assumed that it increases 1% per 10° C., so that at 1,600° C. it would be about 0·3, and if the metal is heated, say, 200° above its melting point, the added energy is 64 k.w. hours per ton. If the metal is put into the furnace at say 180° C. instead of at 30°, the average specific heat being 0·115 × 1·21 or 0·14, the energy saved is 65 k.w. hours per ton, amounting to fully 15% of the above 424 units.

It has been found in practice that a supply of 25 k.w. to the furnace, in addition to the 5 k.w. taken by the transformer, is sufficient to provide all loss by radiation and conduction with a furnace temperature of about 1,600° C., but in actual working, owing to charging and testing the energy required amounts to about 670 units per ton when casting about 2,200 lbs. every eight hours, being reduced to about 600 units when casting the same quantity of metal every six hours.

During August the energy supplied to the furnace was 58,656 k.w. hours, there was produced 68·6 tons of nett castings, the estimated metal melted being 76·3 tons, showing 770 units per ton melted; this energy included the amount required to dry and prepare three new furnace linings.

Tests.—The following readings are taken from the running leg, the actual value of the P.F. at any particular load could only be obtained by using a P.F. meter; but, instead, the volts, amperes, and wattmeters are read every half hour, which gives in practice sufficiently accurate results.

(a) Readings on 21st September, 1916, working with full primary winding of 56 turns:—

Volts—296, 316, 316, 312, 306, 310.
Amperes—300, 312, 320, 322, 318, 319
Wattmeter k.w. hrs.—240, 282, 318, 360, 408, 450.
Average. Volts, 310. Amperes, 315 k.v.a., 97·65. k.w. 84. P.F. 0·86.

(b) Readings every 15 minutes for volts and amperes, 16th November, 1916, working on tapping of coil with 45 turns:—

Volts—310, 300, 300, 295, 296, 285, 290, 270, 275, 270, 275, 273, 265, 260, 258, 260, 250, 252, 253.
Amperes—402, 392, 392, 396, 418, 420, 438, 441, 470, 475, 480, 492, 498, 495, 516, 534, 540, 552, 555.
(Half-hour.) Wattmeters—0·3, 1·1, 2·0, 2·8, 3·7, 4·6, 5·5, 6·3, 7·2, 8·0

The watt reading shows a nearly constant difference, the average being 1·712 per hour, the constant is 60, so average k.w. is 103. Considering this to be constant, which it appears very nearly to have been, the average k.v.a. over each hour is 120 at 400 amps., 124 at 438 amps., 131 at 483 amps., 134 at 516 amps., and for the last half-hour 138 at 549 amps., the corresponding values of P.F. are 0·86, 0·83, 0·79, 0·77, 0·75, the latter is the value for the equivalent of 549 × 45 = 24,700 amperes in primary for a single turn winding.

During the month of January, 1917, the furnace meter registered 44,940 electrical units, whilst the meter at the transformer sub-station showed 71,800, giving an overall efficiency of 62.6 per cent. For last month (August) the furnace received 58,656 units, and the sub-station meter registered 89,700 giving on the greater average output an efficiency of 65·5

General.—The financial result of the first few months working was not too promising, many difficulties arising that prevented the desired output being obtained, although the staff and a full complement of labour had always to be available for the expected full production. It is pleasing to be able to record that all through this early period, during each month of which a substantial loss had to be met, the advisers to the Chamber of Mines never hesitated to recommend that the necessary funds should always be forthcoming. Fortunately their faith in the ultimate success of the project, financially as well as technically, has, during recent months, been amply justified.

The following table gives a summary of results for eight months of this year:—

Month.	Output, Tons.	Units of Electricity per ton	Cost of Electricity per ton at ·625 pence. £	Salaries and Wages per ton. £	Total Cost per ton. £
January ...	37·2	1,940	5·05	9·8	20·0
February	33·9	1,980	5·15	11·1	22·8
March ...	46·5	1,800	4·70	9·2	18·9
April ...	37·6	1,830	4·75	11·1	25·4
May ...	53·6	1,700	4·42	7·7	18·8
June ...	60·6	1,630	4·24	7·4	16·0
July ...	72·9	1,400	3·62	5·7	13·8
August...	68·6	1,320	3·44	6·3	13·8

The output is net weight of serviceable shoes and dies, the units of electricity per ton are those metered at the transformer house. It will be observed how rapidly all costs per ton fall when the output tonnage rises.

The steady improvement in the monthly ouput must mainly be credited to the great zeal and energy of the Works Manager, Mr. A. Holdsworth, through whose efforts the time lost in each relining has been reduced to less than 48 hours.

The capacity of the whole plant just described is no doubt very small in comparison with that of others which ordinarily form the subject of communications to the Electrical Institute. It, however, appeared possible that some of the information given will be found useful by engineers who at a future time may be faced with problems of the same character as those referred to in this contribution. The author certainly would have highly appreciated the value of any publication, if such had been available, giving similar data regarding the details of construction and operating results of other electric furnaces.

The Chairman: I think Professors Stanley and Buchanan are to be congratulated on these most interesting, instructive, and eminently practical papers. These papers refer to a subject somewhat outside my own special line of work, and I am not, therefore, in a position to be able to discuss them. But what does strike me forcibly is the fact that so many difficulties cropped up, all of which seem to have been overcome, or very nearly overcome, in connection with this electric manufacture of shoes and dies. It is in a small way only, but of course that does not matter; it is the commencement of a local industry which has been forced on this country owing to war. It will be one of the good effects of the war if, when the war is over, industries of this sort can be kept going. The points are that we are obtaining, with the local shoes and dies, very nearly as good efficiency as that of the imported article. At the moment, about 10 per cent. of the requirements of the mines in this respect are being manufactured on the Robinson Gold Mine, apparently, about 700 tons a year, at a cost of £14 as against £35 per ton for the imported article to-day; and, I think, by having listened to these papers we shall all appreciate the better, the work done by the Shoes and Dies Committee. The work of this committee has been given in a very good cause and for the benefit, not only of the local gold mining industry, but of the Empire, when, in times like these, it is essential to save all the shipping for the purposes of war; and it has been done by men who have had other things to do. I wish to propose a hearty vote of thanks to Professors Stanley and Buchanan for having informed those of us who knew very little about it before—I myself have been one—of the amount of excellent work that has been done by the authors of these papers and by the Committee as a whole.

Mr. W. Elsdon Dew (Past-President, S.A. Inst. of Electrical Engineers): Allow me to say a few words in appreciation of the papers which have been presented to the two Societies this evening. Before discussing any of the subject matter, I wish to make a definite proposal and one which I consider of great importance, seeing that the closer working of the Technical Societies is something that we all wish to bring about. We have had described certain work which is of the utmost importance to the progress of South Africa, and I am sure there are some amongst you who will agree with me, when I suggest that this paper, by the two authors who have been so closely associated in the carrying out of this work, should be presented under one title. This occasion is much too important to allow a description of such important work, as the authors have been conjointly associated with, to be described under separate titles. I do not think either paper need be altered to any extent, but I do feel that these two papers can be very properly combined, and published as a combined paper by the authors, Professors Stanley and Buchanan. I believe it is the intention of the two bodies to publish both papers in their respective *Journals*, and I cannot see why, with whatever little changes in the body of the papers may be necessary—and which I know can be easily carried out—the two papers should not be printed, in the respective *Journals* as one under the joint authorship of these two gentlemen.

I would suggest that the title would be more correctly stated as: "The First Electric Steel Furnace in South Africa." I hope my suggestion will not be taken amiss, for I feel that the important information given to us by the authors is worthy of every publicity, and it is only by having these two papers combined that the full benefits will be available in connection with technical work. I commend this suggestion to the favourable consideration of the authors and the respective Councils of the Institutions concerned.

Permit me now to congratulate the Societies on having this record placed before them. The information given is of the utmost importance, and, as one who has been closely associated with this first electric steel furnace, I can assure you had this information been available before, it would have saved the Committee of Control a deal of worry. The work of starting any new industry is always arduous, but, in this instance, the Committee had to break a lot of entirely new ground, and the authors have described this in such a form that the information will be of great use to others in the future. As the papers are more descriptive than controversial, I can only record my appreciation of the valuable information contained therein and, when members have been able to study these papers more closely than they have perhaps been able to do to-night, I feel they will be able to appreciate the more the value of the detailed information given, and the records of the successful innovation of the first electric steel furnace in South Africa.

The machinery used has been re-designed and altered to such an extent that it would now be unrecognisable by the original designers, and raw material has been used about which much has had to be proved and applied in a novel manner. The electrical steel furnace is now highly satisfactory, but, as an engineer, I can still see necessary improvements, one of which would be a sufficiently large steam hammer or hydraulic press, with which to put the finishing touch to the steel castings now being turned out. As a demonstration furnace, this one has accomplished its object and, as a result of this successful innovation, the Union Steel Corporation, of Vereeniging, has undertaken, under contract, to instal an electric furnace for the production of 10,000 tons of shoes and dies from scrap, for the Witwatersrand gold mines under the control of the Chamber of Mines. It will be readily realised that, when such an industry is once established, further progress in every direction in the steel and iron industries in South Africa must follow.

Mr. Bernard Price (Past-President, S.A. Inst. of Elec. Engineers): The hour is late, but I would like to express my appreciation of the papers that have been presented this evening, and to say that I feel sure all members of the Shoes and Dies Committee will agree that it is to the two supervising engineers, the authors of these papers to-night, that the main credit is due for the success which has been achieved. The ingenuity and technical skill displayed by Professors Stanley and Buchanan alone enabled the many initial difficulties to be satisfactorily overcome. To me, the outstanding point of interest is the ingenious manner in which material ready to hand has been utilised. The re-modelling of the antiquated electric machines and the way in which the furnace was rigged up from such stampings and other available parts, I think reflects the greatest credit on the authors.

Mr. J. A. Woodburn (Associate, C.M. and M. Society): I should like to add my appreciation to what I have listened to to-night, and I may have something further to say on a future occasion. The only points that occurred to me, while listening to Professor Stanley reading his paper, were whether the mixtures in the furnace would be altered, or whether the shoes and dies as put in varied greatly in carbon composition, and what quantity of pig iron and what quantity of fluxes were added in order to get the required results? I shall probably have something more to say later, but that is one point that occurred to me; as to whether the furnaces would be suitable for smelting with different mixtures?

Mr. J. W. Kirkland (Past-President, S.A. Inst. of Elec. Engineers): I have appreciated very much the two papers that have been read to-night. It is a pleasant occasion when these two Institutions meet together to discuss a matter so important as the beginning of a new industry here. I think the persistence and ingenuity displayed by the enginers who have had to do with this thing is very noteworthy and very creditable to them, and in a broad way, to the credit of South African engineering as a whole. I beg to add my compliments to the authors on account of their papers to-night.

Prof. G. H. Stanley: I should just like to thank you, Mr. Chairman, and the gentlemen who have spoken, for their very appreciative remarks. At the outset, I must disclaim any credit for myself personally in regard to the electrical arrangements; that entirely rests with Prof. Buchanan. I have nothing but a smattering of electricity, and that side has had to be dealt with by him and other members of the Committee. So the credit for most of the improvisations to which Mr. Bernard Price has referred, is entirely his.

To deal with Mr. Woodburn's remarks. If you will look at the analyses on page 74, you will see that there are quite considerable variations—the carbon runs all the way from 0·7 to 0·93 . But our raw material consists, not of one of these imported products only, but of a mixture of any of them that comes along: so that we consider our carbon content of added material is likely to be correct. As a matter of fact, it would be, but it picks up a variable amount of the carbon added to prevent oxidation; we can keep it within limits, but cannot be sure of always having it exactly at 0·8 or 0·9; still, within ordinary commercial limits, we can ensure that our products are of the correct composition. If we wanted to make drill steel, so far as composition goes we could do it, or steel castings with much lower carbon content. In short, the furnace could be used for producing any required steel from raw materials of good composition by making suitable additions; but we cannot use impure scrap. That is the phase of the situation in which the arc furnace is most important.

Prof. W. Buchanan: Might I thank you, Mr. Chairman, and the other gentlemen who have spoken so appreciatively of our work. It occurs to me to make one remark, that is, with regard to Professor Stanley disclaiming any electrical knowledge: he has a lot now compared with what he had a year ago, and I can reciprocate by saying I think I now know a little about metallurgy. I thank you very much.

The proceedings then terminated.

Reviews.

MICROSCOPICAL DETERMINATION OF THE OPAQUE MINERALS.

By J. Murdoch, Ph.D.

New York: John Wiley & Sons. London: Chapman & Hall. Price, 9/6.

The microscopic examination of polished surfaces by means of vertically reflected light so widely used in the study of metals and alloys is now being adopted in the investigation of minerals. Dr. Murdoch's hand-book is chiefly devoted to a scheme for the identification of the opaque minerals based on observations made by the method on 186 definite mineral species, including all these of economic importance.

His classification is presented in a very practical and convenient form, and in the preface to the book by Professor L. C. Graton, of Harvard University, it is stated that anyone possessing common-sense and a good eye can master the scheme.

There is also included a review of the work previously done, and an account of the methods for the preparation of the polished surfaces, and of carrying out the different physical and micro-chemical tests on which the classification is based.

The author explains that the scope of the work is strictly confined to the identification of the minerals and, therefore, one must criticise his proposal to use the name "mineralegraphy," to designate this method of investigation. The idea is that it is analagous to metallography, but metallography means much more than the microscopic examination of metals and alloys. When thermal and structural studies are related to microscopic observations it will be time enough to think about the necessity for a new name.

The only other obvious fault to find is the absence of micro-photographs. Even though the basis of the classification is the colour of the minerals, photographic reproductions would have been most valuable and helpful to the beginner.

As the method of investigation is full of promise the publication of Dr. Murdoch's hand-book is most opportune. It will be of great interest and value not only to mineralogists, but also to the metallurgical chemist, and should open a new field to those studying the economic minerals and who have experienced the limitations of the more familiar methods of examination.

(H. R. A.)

Advanced Text-Book of Magnetism and Electricity, by Robert W. Hutchinson, M.Sc., A.M.I.E.E. In 2 Vols. London: University Tutorial Press. 8s. 6d.

The aim of these volumes to give a clear and comprehensive account of the main principles of the subject in the light of the results of modern research appears to be amply attained. The treatment, while not overburdened with mathematics, requires some knowledge of the notation and principles of the integral and differential calculus for its thorough comprehension. The subject matter is lightened and illustrated by numerous diagrams, which will certainly aid the student to a clear understanding of the principles and methods involved. This work is intended to cover the ground of the final degree examinations of the Universities. Thus far we merely bear out the claims of the preface, and in addition it must be admitted that serious and successful attempts has been made to include all established results of the most recent researches in all branches of the subject extending even to a discussion of the structure of the atom, the quantum theory of energy, the magneton theory, and even the "Principle of Relativity" is mentioned if only to be brushed aside.

It is obvious that a work covering so large an area of ground must be chiefly a compilation, but the selection and arrangement of the materials exhibit considerable skill and judgment, while the inclusion of frequent test questions and exercises will recommend this work to the student who has examinations still in front of him.

(H. A. W.)

Transactions of the Canadian Mining Institute, Vol. XIX., Montreal, 1916.

The chief interest in this volume to members of the Society will be found in the full account of the "Investigation on Rock Crushing made at McGill University," by John W. Bell, M.Sc. This excellent piece of research has already been published in abstract, but full justice cannot be done to it in this manner. Very carefully made and skilfully designed experiment has made abundantly clear that the power consumed in reduction of rock is reflected most accurately by the amount of surface produced, and thus Rittinger's law is substantiated in a far more satisfactory manner than ever before accomplished, and in future may safely be taken for a theoretical basis on which the efficiency of crushing appliances may be calculated, and as a guide to direct further experimental work in this highly important field of operations. Now this matter has been satisfactorily cleared up, attention may be directed to the outstanding feature of all work applied to crushing which the author refers to:—"Apparently the total power drawn by the machine is, for all practical purposes, converted into heat." As on any reasonable assumptions less than one-hundredth of 1% of the power applied is represented by separation of surfaces against molecular attraction, it would appear that a profitable field of research lies open in this direction of obtaining sub-division in some more subtle manner than the application of gross mechanical appliances can ever hope to attain. (H. A. W.)

Reports of the Progress of Applied Chemistry, issued by the Society of Chemical Industry, Vol. I., 1916. Harrison & Sons, London, 1917. 5s 6d.

The form taken by this work has for its apparent object the enabling of those directly interested to keep themselves acquainted with the progress of that branch of technology with which they are directly concerned. Thus under each heading a rapid summary is made of all experimental and other work performed during the period under review, and ample references are given to enable any portion of the field to be more exactly studied. The authors therefore cannot be blamed for the very sketchy way in which an enormous amount of ground is studied and for the superficial manner in which important operations are described. In fact, however, one is irresistibly reminded of a wayside sign-post which shows where to go but offers no other assistance. Fuel and Heating are dealt with by J. W. Cobb, B.Sc.; Gas and Tar Products by E. A. Evans, F.I.C.; Mineral Oils by J. W. Cobb, B.Sc.; Colouring Matter and Dyes by Prof. G. T. Morgan, D.Sc., F.R.S.; Acids, Alkalis and Salts by H. A. Auden, M.Sc., D.Sc.; Glass and Ceramics by J. A. Audley, B.Sc.; Building Materials by J. A. Audley, B.Sc.; Oils, Fats and Waxes by G. H. Warburton, F.I.C.; Paints, etc., by R. S. Morell, M.A., Ph.D.; India-rubber by H. P. Stevens, M.A., Ph.D., F.I.C.; Leather and Glue by J. T. Wood, F.I.C.; Fermentation by A. R. Ling, F.I.C.; Water purification by F. R. O'Shaughnessy, F.I.C.; Fine Chemicals, etc., by F. L. Pyman, D.Sc., Ph.D.; Photography by B. P. Starr, M.Sc.

An immense amount of work is involved in a compilation of this kind, and it is to be hoped that its usefulness is commensurate therewith, but it is somewhat difficult to suggest exactly to whom the benefit will be greatest. To the general reader the highly compressed style, involved in dealing with wide subjects in narrow compass, must of necessity be repellant, while the expert technologist must already have this information at hand though not in such concentrated form. The work, however, may certainly be highly recommended to the busy man of science, who must for the sake of his own branch cast occasionally a hasty glance at the results obtained by workers in other fields, and must for this purpose have succinct and authentic reports available. (H. A. W.)

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

METHYLENE BLUE IN CHEMICAL ANALYSIS, ETC.—"Methylene blue added to dilute solutions of various acids gives fluorescent precipitates of violet or blue. With HI it is blue; $HClO_4$, violet; $H_2S_2O_8$, $H_2Cr_2O_7$ and $HMnO_4$, reddish violet, all reflecting greenish bronze. HVO_3, H_2MoO_4 and H_2WO_4 give blue precipitates without fluorescence. Monnier proposes a colorimetric method based on this class of reactions for the determination of perchlorates in Chili saltpetre intended for use as fertilizer or in the explosives industry. Dissolve 5 gm. of the salt and make up to 100 cc. To 20 cc. of this solution add 1 cc. of a 0·3% solution of methylene blue and allow it to stand several hours. As colour standards prepare 5 tubes with 1—5 cc of a standard 0·1 solution of $KClO_4$ adding to each 1 cc. of the methylene blue and make up to the mark with a solution of C. P. $NaNO_3$. If the $KClO_4$ content is high, the blue precipitate with a green fluorescence appears immediately but with only a trace present it comes slowly. Interfering iodides, which are seldom present, may be removed with Ag_2O; iodates and periodates have no effect upon the reagents."—A. MONNIER, *Arch. sci. phys. nat.*, *42*, 210-6 (1916).—*Chemical Abstracts*, February 10, 1917, p. 239. (J. G.)

NOTES IN REGARD TO TITRATION OF SULPHURIC ACID.—"It is recommended that lacmoid be used in titrations employed for the valuation of commercial H_2SO_4 on the basis of free SO_3 content. In ordinary practice, the NaOH solution used for titration is standardized against $H_2C_2O_4$, $NaHC_2O_4$, or KH phthalate, using phenolphthalein as indicator. When various amounts of acid were titrated with 0·2 *N* NaOH, employing phenolphthalein, lacmoid, methyl orange, and dimethylaminoazobenzene, results with phenolphthalein were always higher than with the other 3 indicators. When 0·1 *N* NaOH was used, Gyzander declares he obtained results identical with all four indicators. Hence it is necessary to make control analyses under actual working conditions before accepting the factor obtained with phenolphthalein as applying to titrations with other indicators. Large temperature changes in the laboratory (28°—0°), also affect the accuracy of measurement of volumes of solutions. C. R. GYZANDER, *Chem. News*, *114*, 260-1 (1916).—*Chemical Abstracts*, February 10, 1917, p. 241. (J. G.)

COLORIMETRIC METHOD FOR THE DETERMINATION OF THE CARBON DIOXIDE PERCENTAGE IN AIR.—"If a current of air containing CO_2 is passed through a solution of $NaHCO_3$ until the solution is saturated with CO_2 at the pressure under which it exists in air, the H-ion concentration of the solution will depend on the relative amounts of $NaHCO_3$ and CO_2 present, and this depends on the pressure of CO_2 in the air. The H-ion concentration of the solution is determined by adding a solution of phenolsulphonephthalein and comparing the resulting colour with that of standards made from KH_2PO_4 and Na_2HPO_4 solutions in different proportions. Directions are given for preparing solutions such that their numbers are parts per 10,000 when used with one $NaHCO_3$ solution and parts per 1,000 when used with a second $NaHCO_3$ solution. The accuracy is about 5% of the total CO_2 present. The method is not applicable in the presence of acid or NH_3 fumes."—HIGGINS AND MARRIOT, *J. Am. Chem. Soc. 39*, 68-71 (1917).—*Chemical Abstracts*, February 10, 1917, pp. 241-2. (J. G.)

ANALYSIS OF MOLYBDENUM ORES.—"The following method for Mo ore analysis, giving a quick and accurate return not only of Mo but of SiO_2, Cu, Fe, Pb and Bi which often accompany it, was devised to overcome two common sources of error: (1) the simultaneous reduction of some of the hexavalent Mo to lower forms on the addition of H_2S, with the precipitation of the greater part as MoS_2, and (2) the incompleteness of separation of CuS from the sulphides of the As group in the presence of Mo. Dissolve 2 gm. of the ore in a mixture of 20 cc. HNO_3, 20 cc. HCl and 20 cc. H_2O. After 15 minutes' boiling add 20 cc. 60% H_2SO_4 and evaporate to white fumes. Determine SiO_2 and Pb in the usual way. Boil the filtrate with a few crystals of $(NH_4)_2S_2O_8$ to oxidize to MoO_3, cool to prevent subsequent reduction of MoO_3 by Fe and add H_2S for 1 hour. Boil the solution for a few minutes and filter. Dissolve the precipitate with dilute boiling aqua regia, filter off free S and evaporate to fumes with 5 cc. 60% H_2SO_4. Cool, dilute to 60 cc. and neutralize with dilute NH_4OH solution to distinct odour of NH_3. Treat a white or yellowish precipitate if present for Bi. To the solution add enough acetic acid to give it a faint odour, add 5 gm. AcONa and titrate for MoO_3 with standard Pb acetate, using tannic acid as outside indicator. To recover any Mo that may have escaped the first precipitation add $(NH_4)_2S_2O_8$ to the sulphide precipitate to oxidize Fe and Mo, precipitate and determine Fe and Al in the usual way and repeat the Mo separation with H_2S."—H. Westling and Carl Anderson, *Mining Sci. Press*, *113*, 917-8 (1916).—*Chemical Abstracts*, March 10, 1917, p. 429. (J. G.)

THE COLOUR OF MAGNESIUM PYROPHOSPHATE, ETC.—"A number of observations bearing on the grey coloured $Mg_2P_2O_7$, sometimes obtained. By the calcination of moist $MgNH_4PO_4.6H_2O$ or $MgHPO_4.7.5H_2O$, a white $Mg_2P_2O_7$ is always obtained, while a grey product results if the precipitate is first dried over P_2O_5; the weight of the two is the same. The decomposition of $MgNH_4PO_4.6H_2O$ is not a simple reaction; in some of the side reactions N_2O is given off. The presence of organic matter does not always give a grey product. Whenever grey $Mg_2P_2O_7$ is obtained, the Pt or porcelain crucible is found to be attacked, and the grey product dissolves less readily in HNO_3. White $Mg_2P_2O_7$ is transparent under the microscope, while the grey contains black spots or is wholly black. Lower results were obtained with a double than with a single precipitation; in some cases single precipitation gave very high results, due to adsorption of $MgSO_4$. The grey precipitate is easily bleached with HNO_3, HCl, NH_4NO_3, or even with H_2O; long ignition results in a slow loss of weight."—D. Baraleff, *Z. anorg. allgem. Chem.*, *97*, 149-160 (1916).—*Chemical Abstracts*, March 10, 1917, p. 431. (J. G.)

NEW METHOD OF PRECIPITATING PLATINUM SULPHIDE AND ANALYSIS OF PLATINIZED ASBESTOS.—"Owing to the formation of colloidal solutions, the precipitation of Pt by H_2S is incomplete. Having found that $MgCl_2$ (5% of solution) precipitates all of the Pt from this solution, the author proposes the following exact method for determining Pt: Dissolve 5 gm. $PtCl_4$ in 250 cc. H_2O, dilute 25 cc. of the solution to about 200 cc., acidify with HCl, and add 5 gm. $MgCl_2$ for every 100 cc. of the solution. After saturating the solution with H_2S, remove wtih the aid of a fragment of filter paper the particles of the precipitate which adhere to the sides of the vessel, put the paper in the liquid and boil until the odour of H_2S disappears. Wash the precipitate twice by decantation, using H_2O slightly acidified with HCl, and then wash repeatedly on a filter with hot H_2O + a few drops of HCl. Transfer the moist precipitate to a Pt crucible and calcine. In determining the Pt in platinized asbestos, the addition of $MgCl_2$ is superfluous, since the asbestos contains Mg salts. The determination is carried out as follows: Warm 10 gm. of the asbestos with an excess of aqua regia until the black particles have disappeared and the solution assumes a uniform orange-yellow colour. Transfer the whole to a funnel (the asbestos serves as filtering material) and wash until the washings are free of Pt. Make up filtrate and washings to 1 litre and evaporate 100 cc. 3 times to dryness with HCl. Dissolve residue in 50 cc. of hot H_2O + 5 cc. HCl, filter the solution, dilute the filtrate to 250 cc., and precipitate the Pt with H_2S as before."—V. N. Ivanov, *J. Russ. Phys. Chem. Soc.*, *48*, 527-9 (1916).—*Chemical Abstracts*, April 10, 1917, p. 766. (J. G.)

METALLURGY.

SODIUM SULPHIDE PRECIPITATION.—"Before the war aluminium dust cost 33.82 cents per lb. and caustic soda 2.11 cents per lb. delivered at the Nipissing mine. This was used in the precipitation process described by E. M. Hamilton in the journal of May 10, 1913. In May, 1916, the lowest price at which aluminium dust could be bought was 90 cents per lb. and caustic soda had risen to 5.77 cents per lb. At these prices the increased cost for chemicals used at this mill would have amounted to about $33,000 per year. This condition compelled the immediate adoption of a substitute. Sodium sulphide appeared to present the most promising solution of the difficulty, and experiments were carried out and were so successful that in June, 1916, the process was adopted.

Two objections are apparent in the use of sodium sulphide for precipitation—the first, that complete precipitation could not be obtained without using an accessory reagent; and the second, the difficulty of producing silver sulphide instead of metallic silver. In regard to the first point it was found that the solution could be precipitated to 0·2 oz. silver without an excess of sodium sulphide in the barren solution. The second objection was met by converting the silver sulphide to bullion by using the same principle employed in the desulphurisation of the raw ore before it is sent to the cyanide treatment. This principle is that the various sulphides and combinations of silver are decomposed by contact with metallic aluminium in a caustic soda solution. This is an important feature of the process, since it gives fine bullion as a product at small cost.

Previous Sulphide Precipitation Methods.—In the former days of the sodium hyposulphite process, before silver ores were treated by cyanide, the treatment and marketing of the sulphides produced was the principal obstacle. Various methods were devised for the treatment of this product at the plant, but they were costly and unsatisfactory. The best of them, however, was the Dewey Walter process, in use at the Marsac mill, Park City, Utah. The reactions involved in this process are as follows:

$$2NaAgCy_2 + Na_2S = Ag_2S + 4NaCy$$

$$2Al + 5NaOH + 3Ag_2S = Na_2Al_2O_4 + 6Ag + 3NaHS + H_2O.$$

$$2Al + 8NaOH + 3Ag_2S = Na_2Al_2O_4 + 3Na_2S + 6Ag + 4H_2O$$

The commercial sodium sulphide used is supposed to be $Na_2S + 9H_2O$, which would be equivalent to 32·5% Na_2S. A concentrated form of sodium sulphide can be had, which promises to work up cheaper than the ordinary basis.

By the use of the equation it is found that it would require 0·076 lb. avoirdupois of commercial sodium sulphide to precipitate one troy ounce of silver. In practice the amount required is 0·12 lb.

In the desulphurising operation one troy ounce of silver requires 0·021 lb. of NaOH. This would be 0·028 lb. of commercial caustic soda carrying 76% NaOH. If an excess of caustic is present in the operation, the reaction in the third equation may take place, in which case 0·031 lb. of NaOH is used for each ounce of silver desulphurised. To prevent this taking place, the amount of silver present in the charge to be desulphurised is estimated as closely as possible and 0·03 lb. of commercial caustic soda is added for each ounce of silver contained. The theoretical amount of aluminium necessary to desulphurise one ounce of silver is 0·0057 lb. avoirdupois, the amount actually used in practice being 0·006 lb.

Practical Details of the Process.—"The procedure is carried out by dissolving the sodium sulphide in an iron barrel into which is flowing constantly a small stream of barren solution from the filter press. The barrel is divided by a vertical partition reaching nearly to the bottom. There is an excess of sodium sulphide in the barrel, and the overflow pipe of the opposite side of the partition from the inflow carries the precipitant to a vat, where it is agitated with pregnant solution, which is then pumped to the Merrill filter press. The amount of sodium sulphide added is regulated by a boy, who constantly tests the inflowing barren solution with pregnant solution and with sodium sulphides to determine whether there is an excess of sodium sulphide or unprecipitated silver present in the discharge from the press. The amount of barren solution coming into the barrel, and consequently the overflow of sodium sulphide, is regulated by a valve on the intake pipe in front of the operator. This operation could be carried out more precisely, perhaps, by precipitating a vatful at a time, but in our case the vat capacity was not available. The solution from the filter press is aerated thoroughly in the barren solution vat by air lift and a large circulating pump, the object being to oxidise any sodium sulphide should there happen to be a slight excess in the precipitated solution. The shiftman always tests the solution for soluble sulphide before running it to the treatment vat, and no bad effect has been noticed from this cause. Aeration is used in preference to lead salt, as lead has a bad effect on extraction. A vatful of sulphide precipitates contains 25,000 oz. of silver. This is drawn into a vat, and the proper amount of caustic soda is added, 0·03 lb. for each ounce of silver. The dilution is four parts of solution to one of sulphide, and the strength of the solution in NaOH is about 8%. The pulp in this vat is kept mixed by the usual mechanical stirring device. Over the vat is mounted a small tube mill, which makes 10 r.p.m. The charge of aluminium ingots weighs 300 lb. and fills the tube mill half full. Below the vat is a centrifugal pump which circulates the pulp from the vat through the tube mill for ten or twelve hours. When desulphurisation is about complete, the precipitate rubbed on a piece of paper by a spatula gives a silvery colour and a metallic lustre. It is then pumped to another press, where it is washed for two hours; the resulting product, then mixed with a small amount of water, is charged without drying, to the reverberatory refining furnace, and melted down to bullion, which comes out about 996 fine. The slag is saved and put through a small blast furnace.

The grade of the precipitate depends largely on how well the pregnant solution has been clarified before precipitation, but under ordinary conditions it assays about 23,500 oz. before and 26,500 oz. after desulphurisation. The final product carries from ½% to 1% sulphur. Gold is not precipitated in an alkaline cyanide solution, and copper does not come down if there is sufficient free cyanide in the solution.

Considering the present war price of aluminium dust, the continued use of this reagent for precipitation is out of the question. It would appear, however, that even when prices of all chemicals used return to normal, sodium-sulphide precipitation will be cheaper than the method formerly employed.

Analysis of Precipitate.

	Before Desulphurising.	After Desulphurising.
Ag	81·21	91·72
S ..	12·09	0·58
Soluble in water	2·02	0·52
Insoluble in acid	2·63	3·03
FeO	0·46	0·57
CaO	0·44	0·49
Al_2O_3	1·32	1·55
MgO	0·14	0·16
Hg	0·10	0·11
	100·41	98·73

The precipitate contained no Au, Pb, Cu, Bi, Co, Ni, Sb, As or Zn.

In the following comparison pre-war prices are given; the quantity of aluminium dust used per ounce silver is the average for 1915.

Cost of Sulphide Compared with Aluminium Precipitation.

Aluminium Dust Method.

	Cents per oz. Silver.
0·05 lb. caustic soda @ 2.11c.	0·1055
0·0262 lb. aluminium dust @ 33.82c.	0·8861
Labour, power and workshops	0·1710
	1·1626

Sodium-Sulphide Method.

0·12 lb. commercial sodium sulphide @ 1·89c.	0·2268
0·006 lb. aluminium ingots @ 19·25c.	0·1155
0·03 lb. caustic soda @ 2·11c.	0·0633
Labour, power and workshops	0·3020
	0·7076
Difference in favour of Na_2S method	0·4550

Saving per year—2,000,000 oz. @ 0·455c. $9,100

It has been shown in Hamilton's article that a large part of the saving in the use of aluminium over zinc dust is in the regeneration of cyanide. By comparing the first equation with Hamilton's equation, given here, it will be seen that the regeneration is the same when sodium sulphide is used.

$$2NaAgCy_2 + 4NaOH + 2Al = 4NaCy + 2Ag + Na_2Al_2O_4 + 4H$$

The process as described is limited in its application to silver ores, as gold sulphide is not precipitated. It is possible, however, that the procedure given could be used to precipitate the silver, followed by the precipitation of the gold in the solution by aluminium. R. B. WATSON. *Eng. and Min. Journal*, March 3, 1917, p. 378. (H. A. W.)

MISCELLANEOUS.

Carbon Monoxide Poisoning.—" 'It is a complete misapprehension to suppose that CO forms a permanent compound with hæmoglobin or induces any lasting deterioration in its O carrying power.' CO forms the same kind of a compound with hæmoglobin as O but with an attraction 250 times as strong. Experiments *in vitro* show that it sufficient O be supplied all the CO from CO-hæmoglobin will be displaced and apparently the blood will be as if CO had never been present. The prolonged coma following CO poisoning is not due to retention of CO, but to injury to the brain and other organs due to insufficient O supplied by the blood while the patient was breathing the CO. Similar symptoms appear among transient visitors on high mountains, and are clearly due to deficiency of O. The mere breathing of inert gases deficient in O but containing no poisonous constituent, produces symptoms, degenerations, and subsequent death in all respects like those result from CO poisoning. CO is a physiologically harmless gas, except in its affinity to hæmoglobin. Its toxic effects are wholly due to the inability of the blood combined with CO to transport O to the tissues. There is no reason to believe that either bleeding or transfusion of blood is beneficial. They are more likely to be harmful. Fresh air, with O inhalations for a short time as early as possible after the diagnosis is determined, symptomatic treatment and good nursing are the only means to be recommended. It is just possible that alkali therapy may be beneficial in combating the acidosis induced by the asphyxia."—Y. Henderson, *J. Am. Med. Assoc.*, *67*, 580-3 (1916).—*Chemical Abstracts Jour.*, January 10, 1917, p. 70. (J. G.)

Paper Making Materials from South Africa.—"Tambookie or tambootie grass from the Transvaal has a length of about 5ft. 6in. When heated with NaOH under pressure, it is readily converted into a pale fawn-coloured pulp, readily bleached to pure white. It would make paper of good strength at probably £4 per ton. Papyrus from Zululand has greenish yellow stems 7ft. in length and 1in. in diameter. Its pulp is pale fawn in colour, readily bleached and makes good paper at a probable cost of £3 per ton."—Anon, *Paper Makers' Monthly J.*, *54*, 302 (1916).—*Chemical Abstracts*, January 10, 1917, p. 99. (J. G.)

A Study of the Methods for Determining Air Dustiness.—"The authors compared the three most advantageous methods: (1) sugar filter operated by Wallace and Tiernan pump, (2) Graham-Rogers plate operated by W. and T. pump (3) water spray filter. The samples were taken in a fur hat factory, a burlap factory, a rag-sorting factory and a pearl button factory. A table of results is given from which it appears that the Graham-Rogers plate is inefficient for various types of dust. The water-spray apparatus is as efficient as the sugar filter. The water-spray apparatus has the advantage in that large samples can be taken in the same period of time with great accuracy in the count; also it provides a sample whose dust can be determined by turbidity standards and weighing as well as by counting. The water-spray apparatus is more easily portable, being lighter. Hence for factory inspection the water-spray apparatus is recommended, provided the rate of air flow is not more than 5 cub. ft. per minute. In atmospheres not visibly dusty 200 to 400 cub. ft. of air are required in order that the dust can be weighed. For the weight determination the reading should be carried out to 0·10 mgm. In counting in the Sedgwick-Rafter cell the quarter field should be counted at 5 points—in centre and at corners on two distinct cc. of sample, after standing 5 minutes. A good bibliography on the subject is given."—G. T. Palmer, L. V. Coleman and H. C. Ward, *Am. J. Pub. Health*, *6*, 1049-75 (1916).—*Chemical Abstracts*, May 10, 1917, p. 1228. (J. G.)

Cement for Defective Castings.—"When a casting has a blowhole or other defect in a part where the strength or the utility of the casting is not impaired thereby, it is quite admissible and quite common to fill the whole with some kind of iron cement. The principal ingredient of such cements is iron in a fine state of division, such as is obtained in oil-free iron filings or in powdered cast-iron borings. With the powdered iron there has to be mixed an oxidising agent such as a manganese dioxide, or a substance electro-negative to iron such as sulphur, in a good conducting solution like salt or sal-ammoniac. When water is added to such a mixture galvanic action sets in, ammonia is given off (if sal-ammoniac is used) and the iron swells, by forming iron oxide, and cements the mass together. The substances named are apt sometimes to expand too much when used undiluted. Portland cement may then be added for the purpose of modifying the expansion. The following formula for an iron cement has recently been given by an American authority:

	Parts.
Iron filings	40
Manganese dioxide, or flowers of sulphur	10
Sal-ammoniac	1
Portland cement	20 to 40

Water to form a paste."—*Page's Engineering Weekly*, February 9, 1917, p. 75. (J. E. T.)

Silica Bricks and Some New Uses for Them.—"Silica bricks are manufactured from a sandstone or quartzite of sedimentary origin. In the United States suitable deposits are restricted to certain parts of Pennsylvania, Wisconsin, and Alabama. The ganister rock when crushed should appear splintery, sharp, heterogeneous in form and size, and slightly translucent. A suitable quartzite would contain approximately 97·5% of SiO_2, 1—1·5% of Al_2O_3, and 0·75 ,, of other impurities; it should melt at cone 35—36, expand, and swell without perceptible cracking. The total fluxes should not exceed 3%. Two kinds of silica brick are manufactured: ganister or lime-bond brick, rich in silica, in which the bonding agent is lime, and quartzite brick manufactured from about one part of finely ground clay to two of crushed quartz, and containing 21—26% of Al_2O_3. In the manufacture of lime-bond brick, the crushed rock is ground in mills with about 2% of good lime; the bricks are moulded, dried for 10—20 hours, and very carefully fired. The first stage of kilning, to drive off the moisture occupies three days with plenty of air, in the course of which the temperature rises to 300° F. (150° C.); the intermediate stage lasts for four days with gradually increasing temperature and less draught: the burning proper, with the formation of the clinker owing to the combination of the lime with the silica, lasts for three or four days, the temperature being forced up to 2800°—3000° F. (1540°—1650° C.). In cooling, draughts of cold air must be avoided, and the operation extended over seven days. The composition of silica brick will be approximately as follows:—SiO_2, 96·%; Al_2O_3, 0·90; Fe_2O_3, 0·70; CaO, 1·75; MgO, 0·14; alkalis, 0·39. It is an acid brick, used in metallurgical furnaces operating with acid slags to form a stable lining; it is very soluble in strong alkali solutions, easily attacked by metal oxides and flue dust. It is an ideal material for a high and constant temperature where the chemical action of the slag is not detrimental, but it possesses the drawback of 'sprawling' or disintegrating if subjected to blasts of cold air or irregular cooling when hot; it is also essential to approach the working temperature slowly and evenly until the brick has become properly annealed. Compared with other refractories, silica brick possesses the important advantages of supporting pressures of 75 lb. per sq. in. well above 2,800° F. (1.540° C.) without deformation; the softening and melting points are almost identical at about 3,400° F. (1.870° C.). The bricks expand considerably in kilning owing partly to the conversion of the silica into tridymite, but show a relatively small expansion after the first burning. Silica brick is coming largely into use for the construction of the checkerwork of open-hearth furnaces, with the most satisfactory results. For boiler furnaces it is not so well adapted unless protection from draughts of cold air can be ensured. For the crowns of beehive coke ovens the advantages in structural properties imparted by the expansion properties of silica brick has established its supremacy under exceptionally adverse conditions of cooling. For the lining of lime-kilns, both vertical and rotary, and for cupolas in steel casting, the use of silica brick has resulted in prolonging the normal life of the refractory structures several times over. Similarly in by-product coke ovens and gas-retorts, the advantages derived from the superior properties of silica brick have enabled the industry to reach a stage of development not otherwise attainable, the expansion properties of the silica being particularly valuable in sectional retorts and long coking chambers"—W. Gray, *Met. and Chem. Eng.*, 1917, *16*, 209-216.—*Journal of the Society of Chemical Industry*, April 16, 1917, p. 387. (A. W.)

Review.

Tube Milling. A Treatise on the Practical Application of the Tube Mill to Metallurlurgical Problems. By Algernon Del Mar. Pp. 159. Ill., index. McGraw-Hill Book Co., New York. 1917. For sale by *Mining and Scientific Press*. Price. $2

This enjoys the distinction of being the first work on tube-milling ever written. It is prepared by an engineer of wide practical experience in milling, who has acquired his knowledge by personal application in obtaining economic results, supplemented by wide and appreciative study of the multitudinous contributions on the subject in technical periodicals and in the bulletins of engineering societies. It brings together significant data drawn from the experience of metallurgists all over the world, discussed by a discriminating critic in the light of his own work. It is a handbook of details, presented in orderly manner, that must prove useful to designers of new plants and to engineers in working out their efficiency-problems. Mr. Del Mar is fully aware of the present limitations of ball-mills and tube-mills, and he states that 'every variation of shape and every means of screening to attain capacity with the least expenditure of power' is being investigated by mechanical and metallurgical engineers. The tonnage per horse-power in tube-milling varies from 1 to 2·5, and the latter figure is far above the average. Variations in the character of ore, size of material fed, fineness of crushing, and many other factors, enter into this result, yet it is evident that the output is not great in comparison with the power required. In general it may be said that under what may be regarded as average conditions as to character of ore, and cost of power and supplies, the cost per ton when grinding to about 100-mesh is above 30 cents. In exceptional cases it is reported as low as 10 cents, and Mr. Del Mar discusses an unusual case at the Gold Hunter mill in Idaho where a feed with 94% of plus 35-mesh material was ground to a discharge containing 30% of minus 200-mesh pulp at a cost of 7.3 cents per ton, this including consumption of pebbles and lining, repairs, and power. Improvements in tube-milling that would reduce the cost on average hard ores to 20 cents per ton or less would open up enormous possibilities in the treatment of low-grade ores.

Mr. Del Mar describes in considerable detail all the well-known mills, the Abbé, Herman, Chalmers, Hardinge, Marcy, 'Compeb,' and Marathon, and he explains the special functions of the different types in grinding for concentration and for cyaniding, making comparisons illustrated by screen-analyses of the products. He also goes into detail concerning the factors that govern capacity, the heat generated in crushing, the relation of coarse to fine ore in giving capacity, and the influence of variation of feed upon efficiency, as well as the proper dilution of pulp to obtain the best economic results. The book gives abundant data regarding the El Oro, Globe, Osborne, Miami, Komata, Liberty Bell, and other liners: feeding and discharge devices; power requirements; details of mounting, foundations, and other practical matters which are important in operation. One chapter is devoted to amalgamating in tube-mills, and another to grinding for flotation. It is an eminently useful and usable book, that will commend itself to engineers and mill operators.—(W. A. C.)

Abstracts of Patent Applications.

259.16. William Hawthorn Johnston (1), Charles Ewald Francis (2). Improvements in means for automatically tipping trucks and like vehicles. 21.10.16.

This application is for an improved means of automatically end-tipping trucks in a revolving tippler.

A hooked lever is fixed on the base plate of the tippler, so shaped that one end engages the front axle of the truck while the other end is held down by a spring. This end of the lever is extended to engage with a second lever fixed on the track on the incoming side of the tippler, and so arranged that the incoming truck depresses the outer end and raises the inner end, thus operating against the spring on the first lever, releasing the front side of the truck which is in the tippler and allowing the incoming truck to push it out.

A sliding bolt is also provided on the underside of the base plate which engages with a stop fixed on the track on the incoming side of the tippler; this sliding bolt is connected to a trigger lever which is operated by the back axle of the incoming truck and releases the bolt when the truck is in position for tipping; as the tippler revolves the rear axle of the truck passes forward clear of the trigger lever, and the sliding bolt is free to engage with the stop when the tippler resumes the normal position.

126.17. Albert Francois. Method for sinking a mine shaft in a water-bearing soil, which is weak or porous. 21.3.17.

This application relates to a method for sinking a mine shaft through a water-bearing and porous rock-bed, wherein two cement layers are introduced respectively above and below the water-bearing seam, thus preventing the water from finding its way into the seam and further into the shaft.

A method for sinking a mine shaft as set forth in claim (1), wherein the two cement layers are made by forcing cement grout through long radial bore holes from the shaft bottom.

127.17. Albert Francois. Method of cutting off a large water flow by means of cement grouting while sinking a mine shaft. 21.3.17.

This application relates to a method of sinking a mine shaft, arresting or cutting off the flow of water by spreading a bed or ballast at the bottom of the shaft and building a concrete plug on the same while keeping down the water level, substantially as described for the purpose specified.

In a method of sinking a mine shaft, arresting or cutting off the flow of water by making a floor at the bottom of the shaft, and building a concrete plug on the same while keeping down the water level substantially as described for the purpose specified.

In a method of sinking a mine shaft as set forth in claims 1 and 3, providing the concrete plug with a pipe for the removal of water from below the plug.

In a method of sinking a mine shaft as set forth in claim (5) of the application, providing the top of the pipe with a cover having a valve, this cover serving to close the pipe after the pumping has been stopped, when the concrete has become hard and the pump has been removed.

130.17. Albert Francois. Improvements in or relating to reinforced concrete linings for mine shafts, tunnels and the like. 21.3.17.

This application refers to a reinforced concrete lining for mine shafts, tunnels and the like, in which an outer framework of the metal reinforcement is erected within the shaft, tunnel or the like prior to an inner framework of the metal reinforcement, so that the inner framework can occupy a position which is always outside the zone affected by the blasting operations while the outer framework serves to support a temporary lining and to resist shock when blasting takes place.

A reinforced concrete lining for mine shafts, tunnels or the like comprising a metal reinforcement having an outer and inner framework connected by a metallic lattice or trellis work on which the members are of helical formation, for the purpose specified.

A reinforced concrete lining for mine shafts, tunnels or the like, in which the outer and inner framework portions of the metal reinforcement are connected together by helical or other members of the lattice or trellis work in such a manner that the whole reinforcement is rendered flexible and permits contraction of the concrete to take place freely, substantially as described.

152.17. John Herbert Veasey. Improvements in automatically fed rock drills. 29.3.17.

This application refers to a combination of a rock drill cradle having means for mounting a rock drill for longitudinal movement, a feed cylinder within the hollow of the cradle, and having means for securing a rock drill to it, and a piston in the cylinder rigidly connected to the cradle by means permitting longitudinal movement of the cylinder in the cradle.

In a fluid feed arrangement for rock drills, a feed piston working in a feed cylinder arranged to carry, on one side of the piston, liquid for controlling forward movement of the drill, means for applying constant gaseous pressure on the other side of the piston for feeding the drill, and means for admitting liquid under pressure to the liquid side of the piston for retracting the drill against the gaseous pressure.

286.17. John Peterson. Power developing and transmitting device. 1.6.17.

This application refers to the combination of parallel frames, internally and externally toothed hubless gears arranged between said frames, transmission gears meshing with the external teeth of said hubless gears and supporting them in a suspended position. Power generating units which include pinions co-operating with said hubless gears and hubless generating gears which co-operate with the said pinions and means for exerting a pressure between the generator unit pinions and the hubless gears and the generator gears.

313.17. Ray Chauncey Newhouse. Grinding mill and tumbling comminuting bodies therefor. 8.6.17.

There are seventeen claims which refer to specially constructed balls, called comminuting bodies for use in tube and ball mills. The special construction claimed consists of a spherical body having one or more re-entrant or concave surfaces, also curved or spherical in shape.

Changes of Address

Adam, A. S., l/o Brakpan; New Primrose G.M. Co., Ltd., P.O. Box 193, Germiston.

Cooke, R. C. H., l/o Benoni; Jupiter G.M. Co., Ltd., P.O. Box 8, Germiston.

[illegible], W. L., l/o New York; c/o Consd. Mines Selection Co., Ltd., P.O. Box 1048, Johannesburg.

James, Alfred, l/o 78, Victoria Street, London, S.W.

Williams, Gilbert W., now Major G. W. Williams, M.C., R.E., Third Division Headquarters, B.E.F., France. (Journals to 87, Bethune Road, Amherst Park, London, N.16.)

APR [illegible] 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII. OCTOBER 1917. No. 4.

Proceedings
AT
Meeting of the Society, October 20, 1917.

The following was the attendance at the meeting of the Society called for the 20th October, 1917. Mr. G. Hildick Smith (President), Messrs. H. A. White, F. W. Watson, E. M. Weston, J. E. Thomas, Prof. G. H. Stanley (Members of Council), R. W. Bennett, R. C. H. Cooke, G. Melvill, J. Thorlund (Members), O. A. Gerber, J. A. Woodburn (Associates), L. B. Eames and Fred Rowland (Secretary).

For the first time since the Society was founded, there was no quorum of members, and the proceedings were merely informal. Mr. Eames kindly read his paper on Diaphragm Pumps, which was received with appreciation, and the contributions to discussion were handed in for publication.

THE APPLICATION OF DIAPHRAGM PUMPS TO METALLURGICAL WORK.

By L. B. Eames, M.Am.I.M.E.

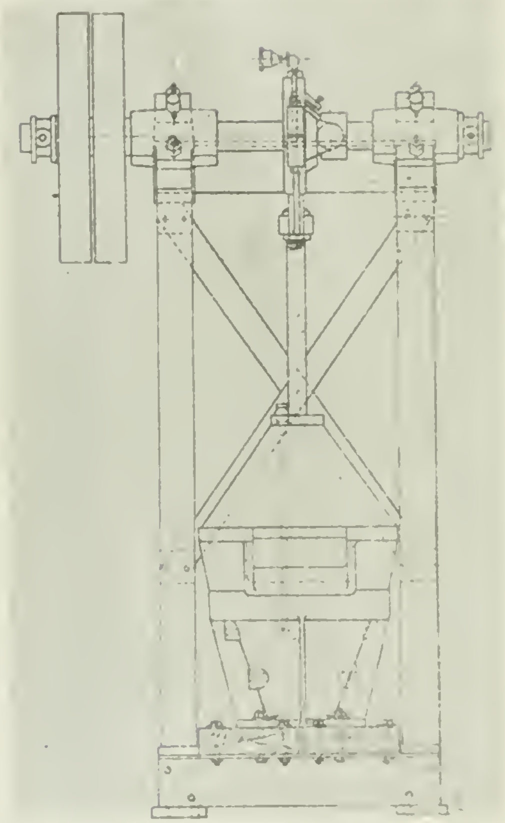
The diaphragm pump was first used, so far as I know, as a hand pump for clearing shallow excavations of water. It was and is popular with contractors, as it can be made portable and can be operated by hand. I have no doubt that diaphragm pumps are doing their bit in Flanders to-day in keeping the trenches dry.

The first metallurgical use for the pump with which I am familiar was a circulating pump for keeping the loading vat of a Moore filter plant clean and the pulp uniform. It has been used also in chemical processes, where acid material is to be handled as in leaching copper bearing slimes and in the manufacture of phosphoric acid. The principle use has been in counter-current decantation plants for controlling Dorr thickeners and transferring pulp between them. A thicker and more consistent underflow can be secured by means of it than by any other means that has been tried.

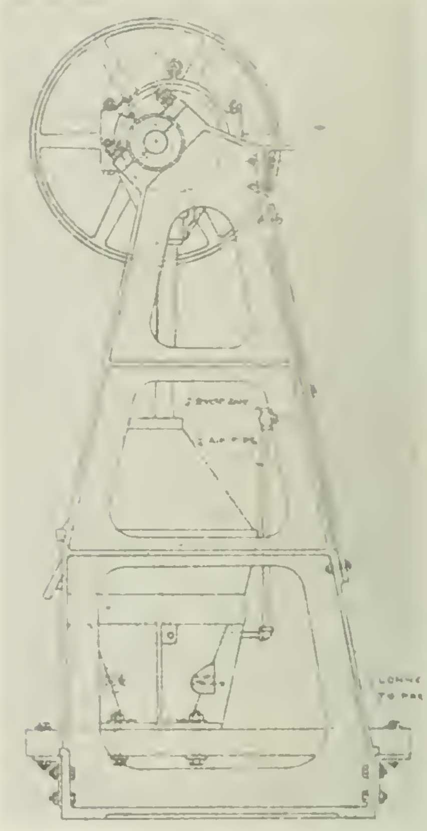
The pump might be described as a chamber closed on the upper side by a flexible diaphragm. The suction pipe enters the base of the chamber, while the discharge takes place through the centre of the diaphragm at the top. Suitable valves are placed at the suction and discharge openings, while a connecting rod attaches to the upper valve seat through a yoke. Through this yoke the centre of the diaphragm is given a short reciprocating travel, while the rim of the diaphragm is fast to the rigid walls of the chamber. This causes the volume of the chamber to alternately increase and decrease, resulting in a pumping action. The liquid after passing through the upper valve is discharged through an open spout. The diaphragm is a dished rubber sheet, 15 in. in diameter with a 6 in. hole in the centre for the valve. It is about $\frac{3}{8}$ in. thick, and has a single ply of loosely woven duck imbedded in it.

There are decided limitations to the ability and usefulness of the pump. It raises material by suction only, so that it can never be used for high lifts. The height of the lift is further limited by the ability of the diaphragm to stand up under the combined tension and distortion caused by the action of the pump. In case the suction becomes clogged, a nearly perfect [illegible] on a No. 1 Geald diaphragm, represents a pressure of 1,100 lb. at this altitude. Experience has shown that a continuous running power driven pump cannot be properly operated at a lift of much over 8 ft. and 4 ft. is preferable.

Speeds from 15 to 100 strokes per minute have been tried in commercial work, the



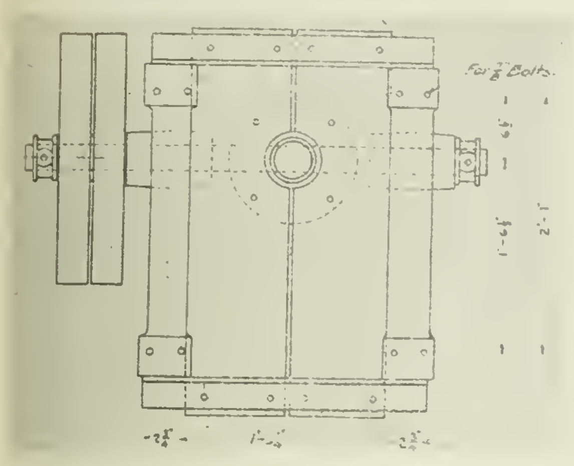
Diaphragm Pump—Front Elevation



Diaphragm Pump—Side Elevation

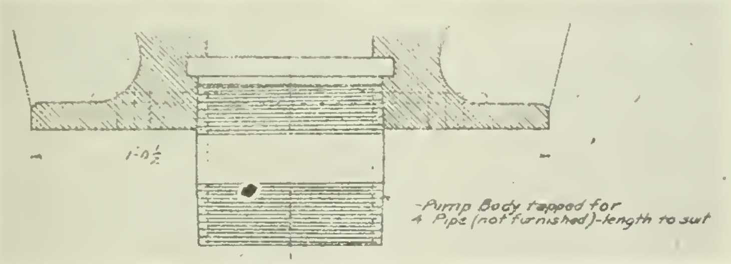
higher speeds in conjunction with a shorter stroke. The evidence seems to be in favour of speeds under 40 strokes with a length of stroke as great as the diaphragm will safely stand. At the lower speeds, pulsation is eliminated and diaphragms have a longer life. With the standard No. 1 Geald diaphragm, 3 in. seems to be the best length of stroke. A large proportion of the diaphragms used at this stroke and at a speed of 14 to 18 strokes per minute, lifting 4 ft., gave a life of over a year. Diaphragms cost from $2.50 to $4 in America, or the equivalent of 10 to 16 shillings. The capacity of a No. 1 Geald diaphragm at 3-in. stroke is equal to 0.11 of a cubic foot per stroke. This corresponds to 120 tons of dry solids per day at a speed of 20 strokes per minute, and a pulp of 1·6 specific gravity.

When first applied to metallurgical work, one pump was installed exactly as it is found in the contractors' work, and with no alterations save the [illegible] drive [illegible] satisfactory diaphragm, the only valve having parts in contact with the pulp are the valves, and these proved a source of trouble at once. In some of the early pumps the suction valve could not be removed without disconnecting the suction pipe. Metallurgical pumps are now made with the valves placed one above the other, and the lower or suction valve accessible through the upper valve seat. Early pumps were fitted with disc valves of a piece of leather or rubber weighted in the centre and [illegible] clamped to the valve seat by [illegible]. These were seldom perfectly tight, and if tight when installed would soon develope leaks, due to wood pulp or waste catching in the hinge joint. These leaks once started were rapidly enlarged by the scouring action of the pulp passing through, so that the greatest care could not prevent the formation of a permanent leak in a few days' time. After various types of grid and ball valves had been tried a simple floating valve seating on a plane circular seat was tried. The valve consisted of a soft rubber disc reinforced at the back by a cast-iron plate, and guided to its seat by cast-iron prongs on its lower side. In this valve the whole circumference of the seat is washed by pulp at every stroke, and any grit, waste, or other foreign matter that lodges once will be washed away on the next stroke, while the soft rubber valve will close over these small irregularities and prevent the destructive leak. With this type of valve soft cast-iron seats would last about one year, but it was later decided to try a soft rubber seat as well. The first one tried was removed for inspection after six months, during which time it had passed approximately 13,500 tons of solids. The seat was in perfect condition, the tool marks on the rubber still showing distinctly. The rubber seat has the added advantage that it can be placed and later turned over and replaced without taking the pump apart, while metal seats must go to the machinist for repairs. The suction pipe is either 3 in. or 4 in. to reduce friction on the thick material handled. This gives a velocity of 20 ft. to 40 ft. per minute at ordinary speeds. For this very reason it is necessary that the pulp pumped should be kept thick unless absolutely free from sand as at these low velocities, the smallest proportion of sand dropping out of the stream would soon choke the line. There is never any trouble from this cause when the moisture is below 50%, even though the pump may stand idle for several hours, due to lack of power or other cause. With the normal thick pulp it is not uncommon for small pebbles and even small metal objects like nuts to pass through the pumps.

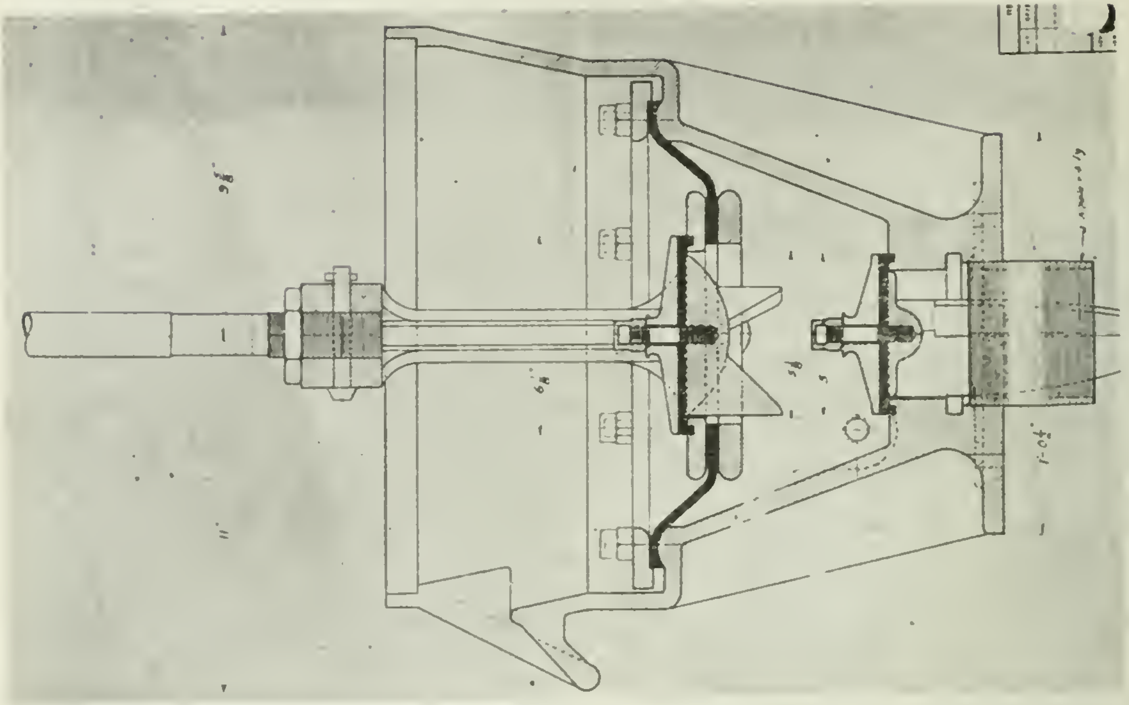


Diaphragm Pump: Plan.

For the low lifts used, power is almost negligible. It is seldom easy to get a measurement on such small amounts, but in one instance where 24 triple pumps or 72 diaphragms were run from one motor through about 150 ft. of shafting, the motor input was 11·1 H.P. These pumps were averaging 17 strokes per minute, and lifting about 4 ft., and handled 1,600 tons per day four times, or 6,400 tons per day once. Capacity is governed by changing speed with a cone pulley, or by varying the length of stroke. I prefer the change of speed because it requires no tools, and operators will do it when conditions require it. Atmospheric air admitted to the pump chamber by a needle valve can be used to reduce the

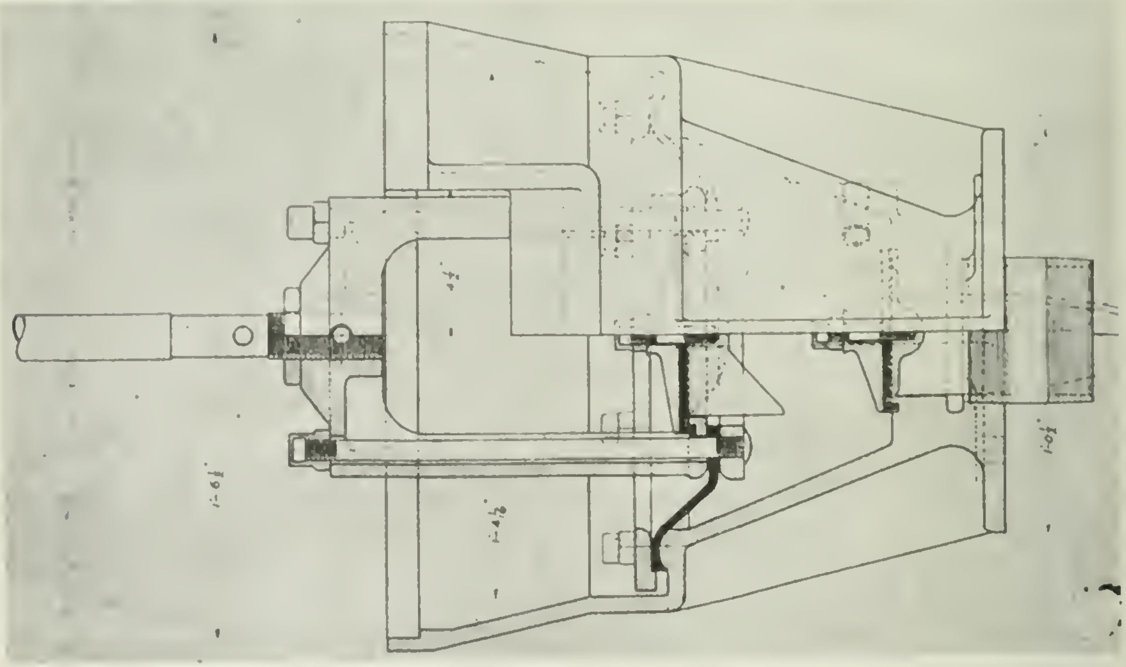


Suction Connection for Diaphragm Pump.



Full Section of Pump Chamber.

volume pumped, or if two or more diaphragms are drawing from the same vat the upper valve can be removed from one unit until the pulp thickens again. When drawing from a thickener adjustments are not very frequently required as there is



Half Section of Pump Chamber

usually a considerable reserve of finished pulp in the vat, and this must be exhausted or built up before a change is required.

To conclude, it may be said that while the diaphragm pump has definite limitations, due to its vacuum lift and to the nature of the diaphragm, still for low lifts on gritty or acid material it furnishes a reliable and cheap means of controlling and lifting liquids and pulps.

NOTES ON TREATMENT OF PILGRIMS REST ORE.

By Robert Lindsay (Member).

(Printed in Journal, April, 1917.)

REPLY TO DISCUSSION.

Mr. R. Lindsay *(Member):* I must thank the President and members who took part in the discussion, and a few of the contributions call for a reply.

An analysis of the ore asked for by Messrs. Crosse and White is given in the July *Journal*, p. 27.

Mr. Crosse's contribution to the discussion was somewhat disappointing, especially in view of the fact that he had spent many months in the district, and had devoted his whole time to experimenting with the ore on the farm Frankfort in this district. Mr. Crosse mentions the beneficial effects of air agitation, which are undoubted; but something more than this was surely required as the process outlined by Mr. Crosse has not been followed by the parties concerned, who are to-day not working any profitable process on their 8 dwt. ore. It would have been interesting to hear from Mr. Crosse just what difficulties he encountered when conducting his experiments, what total extraction was shown, and the cost of obtaining same.

Mr. H. A. White's suggestion regarding the removal of the copper or the influence of its presence by other than acid re-agents is interesting, and recalls the experiments of Jarman and Brereton* on the use of ammonia and its compounds in cyaniding cupriferous ores. The object which these investigators had in view was the "discovery of some solvent possessing a more highly selective action for gold in the presence of copper carbonate than is possessed by potassium cyanide itself. Such a solvent would render possible the extraction of gold from oxidised cupriferous ores without a large consumption of the solvent, and the solutions would be less cupriferous than plain cyanide solution. This being so, the zinc box difficulty would be greatly modified if not wholly overcome." Although Jarman and Brereton's results showed that a mixture of ammonia and potassium cyanide forms a much more effective solvent for gold and dissolves less copper than does potassium cyanide alone, they held out no strong hopes that such solutions as were employed in the experiments would work profitably on a large scale. Moreover, the experiments did not admit of the investigation of the important question of recovery of the gold and copper from the solutions and the fouling of these solutions.

J. Irving† describes a process of leaching ores with sulphuric acid, and although rather outside the scope of cyanide operations proper, it is worthy of note in so far that a fairly high gold and silver extraction is claimed when salt is added with the acid liquors. The method is described as leaching with sulphuric acid and recovering the copper by precipitation on iron with the exception that in this instance the iron is not all lost, and the process is cyclic in operation. The solution from the cement copper vat is pumped back on to the ore charge as a preliminary wash previous to the acid wash, and it is claimed that this reduces the acid consumption on ores containing considerable quantities of acid consuming material such as lime, etc. Further, that with the addition of salt and working on raw material, gold and silver is removed with the copper at one and the same time, the extraction varying in different ores from 56%—92% Cu, 60%—83% Ag, 41%—75% Au.

Although the process above outlined would appear to be applicable only to ores containing high percentages of copper, it is of interest from the point of view that gold and silver can be extracted by it in fairly large proportions.

In further reply to Mr. White regarding the action of copper compounds in decreasing gold extraction, it may be stated that the extraction is affected by the rapid reduction in cyanide strength of solutions already very weak, and that is why a 15 day treatment is required for sand; also, the copper remaining in the residue (about 2·5 lb. per ton at Vaalhoek plant) has a considerable portion of the residue gold associated with it.

---

* Trans. I.M.M., vol. xiv., p. 289.

† Bull. I.M.M., No. 153, p. 37.

Messrs Thomas and Melvill's reference to copper in Rand ore, and Mr. Thomas's trouble in smelting gold slime containing a considerable amount of copper is noted with interest, but the President's statement that the quantity of copper in the Rand banket is practically negligible is, I think, correct. The large amount of gold-bearing solution by-passing the extractor boxes, referred to by Mr. Wartenweiler, is carried out with the object of avoiding large quantities of very low-grade solutions going to the boxes. The amount of gold dissolved by each wash is very small even when kept under contact. The greater proportion of the gold is precipitated in the *metallic* form along with the copper in the first compartment, and there is practically no black gold slime found under the screen trays. The metallic gold flakes can be easily seen in the acid-treated gold slime when thinned down with water.

I must thank Mr. Andrew King for his able contribution and his close study of the paper is appreciated. Mr. King does not consider it quite a safe practice to convey the overflow from tube-mill feed cone to return sand spitz, but by a slight overlook he omits to state the reason. The washing device used in cone "G" is that introduced by Mr. Brazier some years ago, and it gives a very clean sand. The top vat marked "A" is not used as a collector, but wholly for treatment purposes, and the question of soluble gold in the water from the slime collectors overflow does not arise. The sand last drainings shown are admittedly a little high in cyanide strength, and an extra wash with precipitated solution from the slime plant reduces the value from 0·027 to 0·023% KCN when time permits. Mr King suggests an increased ratio of solution and fewer transfers. This has been attempted many times: a change over from the collectors every 8 instead of 12 hours, when number of transfers were reduced by two and always with the same result: an increased residue of 0·2 dwt., and a speedy reversion to the treatment as described in the paper. Mr. King refers to the unusual method of using cocoa-matting as a partition across the settling vat for slime solutions. These vats were recently cleaned out after a 16 months run, and were estimated to contain 40 tons of dry slime, or just over 1 lb dry slime per 100 tons of solution. I only mention this figure in order that Mr. King may determine whether he is correct in assuming that the solutions here are less cloudy than elsewhere. Very little ore slime reaches the extractor boxes, otherwise a 30% gold slime for smelting would be a rare occurrence. The flaky nature of the slime (which soon chokes a sand filter) as well as the quantity has to be considered. It may be mentioned that experiments made some years ago with the object of installing a Butters' filter were so unsatisfactory that the idea of installing the filter was abandoned.

Mr. L. W. Macer's contribution to the discussion is most welcome, as he has had the experience of experimenting on one of the local ores on a working scale. His record of laboratory trials on the ore previous to deciding on the most suitable plant are of much interest, and he appears to make out a good case for the selective grinding action of the slow-speed Lane mill. Mr Macer's evidence of no gold being attached to the heavier particles of ore is confirmed by the investigations at T.G.M.E. Central Works over two years ago. These investigations showed that from 13,000 tons of ore milled not more than 0·75 ton of concentrate assaying 60 dwt. per ton could be collected.

Mr. Macer gives his total extraction at 92%, which is fully 2% below that obtained here, and he invites discussion on (1) selective grinding by Lane mill, (2) continuous decantation, and (3) precipitation difficulties in the presence of copper.

Regarding (1) and (2), Mr. Macer makes it rather difficult to discuss them, as he has omitted the important item of costs; for instance, a statement of the cost of installing the Lane mill, its capacity and running cost over a reasonable period, of say, six months actual running time would have been useful. Regarding (3), this has already been dealt with in the paper with the omission that the zinc is cut to $\frac{1}{200}$ in. thickness, this being the most serviceable.

Mr. H. A. White's further contribution to the discussion came to hand after the foregoing had been written. The question of the use of ammonia in some form has already been dealt with, and the writer is much indebted to Mr. White for the information that the manufacture of carbonate of ammonia is now a South African industry, and possibly it is being sold at a price which will encourage an investigation towards its profitable use on cupriferous gold ores and provide matter for an interesting future paper. The precipitation of the copper from such solution could be accomplished by slightly acidifying with sulphuric acid before coming in contact with the iron.

Tube Mill Plant.—Mr. White makes reference to the low production of −90 grade per tube. It is found that the finer the pulp a lower tonnage must be fed, thus giving a low tube mill efficiency. If pyrites had been present in the ore, and such pyrites carried the gold, it would be better to let the mill pulp go to two tubes, classify the tube outlet pulp, and pass the coarse portion to the third tube mill. A higher tube mill efficiency, of course, would be obtained if fewer stamps were used with a coarser screen, but this is beyond the jurisdiction of the writer.

Sand Treatment.—Mr. White says "an examination of the chart supplied indicates that probably the gold is all dissolved during the first five washes." The chart does not indicate this, but shows that the average residue after the first five washes to be 2·6 dwt. The reason for by-passing is this: that early leachings from one charge show as high values in cyanide and gold as if one were treating Rand ore, while a few days later leachings from another charge show no free cyanide and very little gold until the fourth and fifth days. Would Mr. White pass such solutions to the boxes? The present treatment is designed to meet these variations and to avoid the procedure of passing these solutions to boxes one day and by-passing them the next.

The figure of 6 lb. of lime per ton of sand is not a misprint. The lime consumption is, and appears to be due to the presence of free or loosely combined silicic acid in the ore. This point will presumably have to be kept in mind when using any process involving the use of ammonia.

The slime solution clarifiers are 20 ft. dia. by 5 ft. deep. Across the middle of the vats a double sheet of cocoa matting is suspended, and is fastened to the sides and bottom. The solution flows in on one side at the top and escapes near the top at the opposite side into another similar clarifier. The vats are thus always full of solution and any fine slime in suspension becomes entangled on the surface as there is not great force behind it to drive it through. As the slime slowly accumulates on the matting it gradually falls to the bottom of the vat, leaving a more or less clean surface exposed for a long time. It suits the local slime very well, and avoids the continuous cleaning out of sand filters, but to say that it is superior to Rand practice would hardly be a fair statement until it had proved suitable to Rand ore slime, and which is doubtful.

I must express pleasure of having had the opportunity of discussing the metallurgy of the ores of the Pilgrims Rest district—a district which has still a future before it, when its various ore not yet worked, are made amenable to profitable treatment, as they undoubtedly will be.

SOME NOTES ON EXPLOSIONS OF FIRE DAMP, AND OCCURRENCES OF GOB FIRES IN NATAL.

By Messrs. J. E. Vaughan (Member) and F. A. Steart (Associate).

(Printed in Journal, June, 1917.)

DISCUSSION.

Mr. W. Taylor Heslop *(Member)*: Messrs. Vaughan and Steart do not claim to have raised any special new points in the half of their paper dealing with explosions of fire-damp or coal dust, but their paper is sufficiently suggestive to call for comments on one or two points. They state: "We have little hesitation in saying that all of these (explosions) would have been prevented had the present mining regulations been in force, and what is more important, rigidly adhered to by all concerned." This paragraph is like the proverbial bee—the point that really matters is in its tail. Regulations may be framed after careful consideration, and embodying the results of long experience, but in such a case the ratio of human fallibility and frailty steps in, and altogether upsets the calculation. The Inspector of Mines can easily say "the regulations are there, and they must be observed." The mine manager, on the other hand, knows very well that he is working with imperfect human tools, from his staff down to the humblest nigger, and, however, much he may work, or however strict he may be, he knows that regulations will be broken. He has therefore to put his precautions for safety on a broader basis than the limits of mining regulations, if he wishes to work with effective safe-guards. The writers specify four different *direct* causes of explosions.

Let us forget the mining regulations for the nonce, and consider some *indirect* hypothetical causes of explosions and other accidents. To begin at the top, an over-anxious managing director worries too much about output and costs, and a manager may possibly be so pressed, that he tries to escape paying the price of safety, and takes undue chances; and the same kind of spirit may filter down from one official to another until it reaches the lowest grade of employee.

At another mine the sociological factor, in some way or other, does not count for much, and it is the refuge for all the "wasters" on that particular mining field. Naturally, in such case the ratio of human fallibility is unduly high, and the effect on mining regulations unmistakeable.

Let us turn to some engineering points. A manager may have been over anxious, and carried his ventilation brattices so close, that he has placed too much resistance on his air current. Another, by careful timbering, has avoided falls in old workings which might interfere with air currents, and so on. Safety may be gained or lost by a variety of factors, and by careful study, or otherwise, of conditions and methods, altogether apart from mining regulations. Let me give another illustration: years ago I noticed that in development drives the pressure of gas broke down the roof, consisting of laminated sandstones, between the two seams. A series of boreholes liberated the fire-damp at points where it could be taken direct into the returns, and relieved the roof pressure. Later two drives through a dyke, one in the top seam and the other in the bottom seam, liberated hardly any gas, until the same laminated sandstone was blasted through to make the return connection, and then, very large quantities of gas were liberated. In a recent issue of the transactions of the Institution of Mining Engineers Dr. J. S. Haldane states that solid coal is almost impermeable to gases, confirming my practical observation that the permeable sandstone was the conduit for the gas. That knowledge has a distinct practical bearing on safety, but the mining regulations have nothing whatever to do with it.

Our mining regulations are very full and complete, and administered with zeal and discretion; but for the improved record of safety, we have mainly to thank improved mining methods, and increased knowledge and skill by all ranks from manager to black man. Twenty years ago 90% of the natives were absolutely raw. Now 70% have had previous mining experience.

The writers' comment on the cost of a big explosion. It is absolutely no exaggeration to state that directly and indirectly, the two principal explosions in Natal cost nothing less than £150,000, and neither of them are yet fully paid for.

When we turn to gob fires, the writers of the paper give us the benefit of many original investigations, and I should like to record my appreciation of the keen interest they have taken in the many scientific and practical points in connection therewith.

I, however, join issue with them on the first two paragraphs, under the head of "Causes of Spontaneous Combustion." I may claim to be the original advocate of the theory that in Natal the anthracitic coal is more liable to spontaneous combustion than the bituminous. That theory is empirical, and I cannot yet give a scientific reason for it. There are, however, some suggestive scientific parallels. We know that spontaneous combustion is due to oxidisation. We also know that a very large number of substances, including many of the alkalies, have an affinity for oxygen after being exposed to calcination heat, which they did not possess before. The anthracitic coals of Natal have been exposed to considerable heat from the igneous rocks in their proximity, and that heat may have effected chemical changes not yet determined. In every outbreak of spontaneous combustion at St. George's Colliery I have been able to trace the origin back to semi-anthracitic coal. On the other hand, several areas have been laid down in goaf where top seam coal has not been worked, and where the coal is bituminous, and no trace of fire has ensued.

It is a well-known fact in British mining practice, that when a fire has been extinguished by flooding, it will re-start very soon after the water is pumped out, showing that an old fire, *i.e.*, coal that has been heated, is specially liable to re-heat. If the heat of a recent fire has such an effect, why should the heat of a pre-historic plutonic fire not have the same effect.

In using the term anthracitic in this context, I take it in its widest sense, *i.e.*, that the coal has been subject in some degree to the heat of igneous action. In some recent coking investigations I found that a certain area had been subjected to igneous action, because its coking qualities had been slightly impaired, although the coal had only lost from 1% to 2% of volatiles, and still contained 20% of volatile matter. When the writers therefore instance a recent fire where the volatiles were 20% I cannot accept that as proof that the coal had not been in some degree affected by the overlying igneous sheet, until they can prove that the coal still possessed full and unimpaired coking qualities.

The writers quote South Wales conditions where anthracites and semi-bituminous coals do not fire. Curiously enough in the Transactions of the Institution of Mining Engineers. Vol. LIII., part 4, just to hand, the President in discussing Dr. Haldane's paper on the spontaneous firing of coal, quotes a letter from J. T. Forgie, describing how the coking coal of Kilsyth, in Scotland, was more liable to fire than adjacent semi-bituminous seams, and how that same coking seam was intersected by whin dikes, and in a special case, driving through a dike, the coal proved extraordinarily liable to rapid spontaneous combustion.

It appears from this quoted case that a coking coal, from which a portion of the volatiles had been driven off by igneous heat, was more liable to spontaneous combustion than the remaining portions of the seam not contiguous to the whin dikes. It also appears that the adjacent semi-bituminous, and non-coking seams, were not so liable to fire, even in the places adjoining the dikes, where they would have been subjected to igneous heat.

In South Africa some non-coking coals have shown a distinct liability to spontaneous firing, for example, the inferior coals of Boksburg, Brakpan, Vereeniging, and South Rand, whilst the better class coals of Middelburg have been generally free from similar liability. That would seem to point to another cause of firing, perhaps peculiar to the inferior coals or inferior portions of the seam.

As far as Natal is concerned, I have yet to learn of a fire that could not be traced back either to coal which had been subject to igneous action, in greater or less degree, or else has occurred in a seam which contained a band of very inferior coal.

The evidence I have collected is sufficient to justify further investigation, and its confirmation, either by accumulated evidence, or by chemical or physical experiment, would justify managers in taking special precautions when extracting coal near dikes or intrusive dolerite sheets.

With the conclusions drawn by the writers, I agree with all except the latter portion of No. 6. The only safe mining practice in building off a fire is to take the fresh air in with the working party, and that means commencing from the intake side, and not the return. Under certain circumstances, building might be commenced from both sides, but if that is done a door should be left in the last return stopping, and not closed until all the other stoppings are completed. In any case, the last two or three stoppings are likely to give a considerable amount of trouble.

With the possibility of explosive gases accumulating within the stopped area, it is always imperative to keep the closed off area as small as possible, and the stoppings as close as possible to the goaf. In the one case (the Natal Navigation) where the fire culminated in an explosion, it would have been very interesting if the writers had given more details, and could have suggested what were the special conditions that led to the explosion, and also detailed the method of sand-filling adopted for the recovery of the mine.

NOTES ON THE SUPPORT OF THE UNDERGROUND WORKINGS OF THE MINES OF THE RAND.

By Percy Cazalet *(Member)*.

SYSTEMATIC PACKING UNDERGROUND AT THE FERREIRA DEEP MINE.

By G. Hildick-Smith, B.Sc. *(President)*, and Paul Selby, B.Sc. *(Member)*.

(Printed in Journal, July, 1917.)

DISCUSSION.

Mr. J. Thorlund *(Member)*: The authors have brought forward a subject of far-reaching importance in its application to Rand mining, not only with regard to the support of workings, but to their development as well. The papers indirectly add another prop to the support of arguments in favour of foot-wall drives, wherever consistency of values permit.

In supporting hanging, whether pillars or packs be adopted, if the overlying rock gives sufficient pressure, the result in both cases will ultimately be the same, namely, the cohesion of the particles of the supporting medium will gradually be destroyed until eventually its stability depends on friction only, in other words, the support becomes pulverised. In old workings it is often difficult to distinguish a pillar from a pack by its appearance. With packs the condition referred to is attained gradually without any active signs of breaking-up, whereas in the case of pillars it is often accompanied by violent explosions, with attendant dangers. Conditions on the Robinson Mine are very similar to those obtaining on the Ferreira Deep, to which it is contiguous, being, if anything, further complicated by a system of dikes running parallel with the dip of the reef, but having, contrary to the general trend of dikes on these fields a very small angle of dip. In later years practically the only pillars or "brackets" left were against such dikes, the adoption of the reef packing system, as described by the authors, having rendered the cutting of pillars unnecessary.

The advantages of the reef packing system as enumerated by Mr. Cazalet might be added to by a very striking example on this mine. Underlying the Main Reef Leader under a thin parting is the Main Reef proper. In some instances the parting is sufficient to enable the Main Reef to be worked separately (to be described later) but where it is too thin, the width of the Main Reef, 6 ft. to 7 ft., would, if added to the original width of the Leader bands, have given rise to a stoping width too great for exploitation in one operation, having due regard to safety and the low gold contents of the Main Reef. Consequently the Main Reef was left in the first operation and the Leader stopes reef packed, the average stoping width being 84 in. After a lapse of years the hanging in these stopes has settled very considerably in some cases to as little as 3 ft. Generally, the settling has been very even with little breaking up, and the hanging is now quite "dead." At the present time the Main Reef is being footwalled, the parting of waste being used to fill pigstyes, which are built to replace the Leader fillings as they are extracted.

The gradual exhaustion of block ground on the Robinson Mine rendered necessary some system of support which permitted of the total extraction of the remaining reef, and at the same time would be as efficient as reef packing. With the limited rock available for packing, systematic pigstyeing with 8 ft. × 5 ft. 6 in. gum poles was adopted, and has now been in successful operation for some four years. It is, of course, well known that timber is not nearly so strong across the grain as with it, owing to the fact that stress to a transverse section breaks the fibres whereas to a longitudinal section it separates them, or, the strength along the grain depends upon the strength of the fibres, across the grain on their adhesion. The idea, however, in these pigstyes was to *pack* the rock, not merely filling the empty cribs. In this way, though a certain amount of deformation of the timber takes place, breaking stress is not reached, the main pressure being taken by the packed rock and the function of the poles is reduced to preventing the pack from spreading laterally. The system has been applied to South Reef, Main Reef Leader and Main Reef stopes, with stoping widths varying from 3 ft. to 15 ft., and on dips from 20° to 50° without accidents from falls of rock. While it is probably a little more expensive than reef packing it has met all the conditions that have arisen from work under such varying conditions. Especially has the system been found successful in mining Main Reef separately from the Leader where the parting is 2 ft. or over in width.

A section of the old Worcester Mine is being worked, under a lease from the Ferreira Deep, by this method, particulars of the general nature of the ground being as follows: The Leader stopes in this section were worked some 20 to 25 years ago and have entirely caved. The parting between Leader and Main Reef is a coarse slate, intermediary in structure between the East Rand footwall slate and the Normal Rand quartzite, giving a very friable and naturally weak hanging wall to the Main Reef. The width of this parting is, in the area under consideration, 5 ft. to 7 ft., the hanging being broken at intervals by

(*a*) Old drives, the levels of the Worcester not corresponding with those of the Robinson, from which the attack is made.

(*b*) "Punching" effect of overlying Leader pillars.

The Main Reef consists of two main bands, each 3 ft. wide, separated by a parting of 12 in. to 24 in.

Method of Attack.—The Main Reef is reached by cross-cutting, which is followed by raising with air-fed hammer drills. It is essential (the whole method depending for its success upon this) to raise under the top band of reef so as not to damage the hanging. The raise is then widened by overhand stoping until there is about 20 ft. from face to face; when the hanging band is stripped. Stoping also is done with air fed drills as the vibration caused by a bar-rigged type of machine would damage the hanging. Companion drives to the Leader are carried on ahead of the stope face East and West, being about 12 ft. wide on the dip, thus allowing the first row of pigstyes to be built and at the same time costing little more than ordinary stoping. The face of the stope is carried so as to suit the pigstyes, leaving as little clear space as possible, in some cases only 1 ft. to 2 ft. from face to pigstye.

Details of Construction, etc., of Pigstyes.—The cribs are built at regular intervals, 15 ft. centres and parallel with the dip, affording channels for haulage ways, ore chutes, etc. The poles used are joggled on the surface, the depth of a notch being $\frac{3}{4}$ in.

For support while building, two poles are set up on the dip side of the pack. As the building of the crib progresses it is packed up with waste rock, which is also built in between the lagging so as to stand flush with the outside face of the pigstye. When the hanging is reached the corners are tightened with hard-wood wedges and waste pieces of timber are split up and driven in from all sides between the hanging and top laggings, securing the crib from blasting. The cost of building a pigstye in this mine for an 8 ft. stope is as follows:—

43 8 ft. × 5 ft. 6 in. poles, @ 1/8	£3	12	6
2 12 in. × 7 in. headboards, @ 1/-		2	0
Nails		1	6
1 Rock-waller		10	0
2 Natives		6	0
	£4	12	0

A man builds one pigstye per shift, and where waste rock is available in large quantities can build three packs in two shifts. It has been proved experimentally that timber may be strained almost to the point of rupture without injury to the material. This is taken advantage of when an area has been worked out, the sticks being withdrawn and used over again, and the ground allowed to cave. In one section of the mine it was found possible to work downwards in this way from level to level, the stope above having been worked out, the pigstyes were pulled out and the waste rock also utilised in filling up new pigstyes. Where Leader pillars are observed to have been left by their "punching" effect, the area is supported, the hanging broken through and the Leader extracted, waste rock at the same time being available from the caved stopes.

When permanent ways pass through these areas the channels are secured by re-inforcing the pigstyes by packing waste between them. In stopes dipping over 45° it should be possible to use 4 in. lagging poles, but the length could hardly be increased.

For the above particulars I am indebted to Messrs. Palmer Carter and T. Harris, who have been instrumental in proving the economic possibilities of the system, which will readily be acknowledged, when it is realised that with timber at upset prices, on the Robinson Mine, where there is not to be seen an ordinary stope face or gang of over a dozen boys, the working costs for last year were 14s. 9d. a ton.

Mr. J. A. Woodburn *(Associate)*: It is most interesting to one who has for years advocated coal mining practice on the Rand to read the two papers on underground packing by Mr. Cazalet and by Messrs. Smith and Selby.

It is no new thing to hear that the hanging wall of a reef cannot be kept from subsiding, and that all supports can only allow the roof of the working to subside gradually, as this has been an acknowledged fact for many years in coal mining districts. The same problems were faced thirty years ago, and although coal strata are more varied and not so strong as the quartzites overlying the Rand conglomerates, yet the condition is only a matter of degree, and does not differ much from where three or four coal seams from three to five feet thick are being worked one above the other in the same mine. The formation gradually subsides, and in the early days railway companies bought up large areas of coal from the mine owner to protect railway embankments and bridges, and large pillars of coal were left in to protect houses, works and reservoirs. More recently, however, railway companies often allow the coal to be worked out if done in a systematic manner, and risk the gradual repairs to the embankment or bridge, as the subsidence is often of a very gradual nature, and can be looked after and repaired at less cost than the purchase of the coal.

In August, 1897, Mr. T. E. Parrington, in discussing a paper by Mr. Andrew Burt in the Federated Institution of Mining Engineers, said: "He knew cases where the Bord and Pillar system had been the general method, except under buildings where longwall had been substituted, "the idea being," he added, "that by removing the coal as fast as possible a more even subsidence took place."

On the Rand, mining methods have been more of the nature of getting as much ore out as possible without any thought for the future, and without any defined system of operation, and now when the evils resulting from want of underground systematic working are becoming apparent, instead of admitting that this condition of things was only to be expected, and accepting what has already been done years ago under somewhat similar circumstances, one gets the impression that the Rand is represented as unique, and that some equally unique method has to be devised to cope with these new exceptional conditions.

The fact is that the Rand conglomerates lying interbedded in hard quartzite over large areas conform in every respect to large areas of workable coal seams, and the methods which have been successfully adopted in working these coal seams are the methods that should be adopted here.

In deep coal mining, Pillar and Stall, or Bord and Pillar, or what is called in Scotland "stoop and room" working, has been largely abandoned, and Longwall or modifications of Longwall substituted. That is to say, all the coal is taken out in the first working and the excavated areas systematically built with pack walls and cribs.

As far back as 1892, Mr. Edward Wain, in the Federated Institution of Mining Engineers, dealing with Longwall methods of working, says:—"In view of the rapidly extending use of the Longwall method of coal getting in almost every coalfield of the kingdom, the simplicity of ventilation, the reduced liability to accident from falls of roof and side, and last, but not least, the very great reduction in the cost both of working the mineral and maintaining the workings in good Longwall work, as compared with Pillar and Stall workings, are subjects which might well be considered, but it is hardly possible to deal with them within the limits of this paper, which is intended to be simply a record of how the system has been adapted to certain seams."

These seams were from 2ft. 9in. to 8ft. thick, and dipping at angles from 11 degrees to 20 degrees.

Again, in October, 1901, Mr. John Cadman, B.Sc., in a paper on the "Modes of Working Ironstone in the North Staffordshire Coal Field," says: "The Longwall method of working with various modifications has been adopted with success in the working of these ironstones, although up to recent years the Pillar and Stall method was universally adopted."

The only description of Rand mining in the past would be to call it a distant relation of the Pillar and Stall method.

"It is interesting," Mr. Cadman says, "to discuss the causes which led to the success of one method and the failure of another method of working."

"The causes of failure of Pillar and Stall system include:—

(*a*) Uneven distribution of roof pressure, causing the roof to fracture and the bottom and floor to lift, necessitating high and costly timber expense.

(*b*) Excessive blasting, by which ironstone is broken into smalls.

(*c*) Excessive cost of yard work; and

(*d*) Pillars become crushed and small ironstone is produced in consequence."

Practically all these causes of failure are now showing in Rand mining, as detailed in Mr. Cazalet's paper.

The causes of success of Longwall, according to Mr. Cadman, are:—

(*a*) Even subsidence and distribution of roof pressure, and the timber may be recovered and used over again.

(*b*) Maximum advantage is obtained of the natural jointing, and consequently blasting is not so extensively employed as in the Pillar and Stall system.

In describing the timbering in detail, he says:—"It has been the custom for a considerable number of years to taper all props used in the drifts to allow of even shrinkage prior to the goaf being packed. Chocks (wooden erections) are formed for supporting the roof at the formation of jigs and drifts where packing material is scarce, and the inner space is filled with dirt. The chocks can often be recovered after the settlement of the goaf and used again for similar work.

"Chocks built of stone, called 'Riflemen,' are used to support drifts. These are occasionally built of ironstone, which is afterwards recovered. It is usual to place a little timber on top of 'riflemen' to enable them to take up the pressure."

It will be seen from the foregoing quotations that the ore being mined is often used for packing purposes, to be subsequently recovered, similar to Mr. Cazalet's recommendation that ore should be used in the pack wall on Rand mines.

In December, 1900, Mr. John Gerrard, H.M. Inspector of Mines, in his presidential address to the Midland Institution of Mining, Civil and Mechanical Engineers, speaking of profitable coal mining at great depths, says:—"In working a seam over five feet thick from the surface downwards to a depth of 3,600 feet, it appears to be necessary to rely upon substantially built pack walls supplemented by square wooden chocks in preference to timber props or bars," and adds: "It is impossible to leave other than temporary coal pillars at depths exceeding 3,000 feet."

Mr. Cazalet tells us that the bulk of his notes were written three to four years ago, when, as he says: "The advocates of waste or ore packing, as shown by his and Mr. Smith's papers, were like voices crying in the wilderness."

There is a Wilderness of Ignorance, which may be cultivated, but the Wilderness of Prejudice is a vast and barren desert, of which the Rand has had too great an area.

In the *Journal** of June, 1913, the present writer contributed an article describing a method of working by pig-styes and waste packs, and intermediate tram roads about 60 feet apart between pack walls, and showed a sketch which appears to be much the same as that shown in figure 8 of Messrs. Smith and Selby's paper. The following is a quotation from that article:—

> "These diagonal double tram road ways would have a slope of less than one in three, and be quite suitable for truck haulage on a self-acting incline from the stope face to each box hole. . . . These incline roadways could be made as the stope face advanced, and would be protected by building pack walls and cribs on either side to allow the hanging wall to settle gradually."

This compares very closely with what Messrs. Smith and Selby say in their paper, page 15, as follows:—

> "Intermediate tracks are laid between the packs at distances of about 50 feet apart through the stope. On these the ore is trammed to fixed footwall chutes. . . . The packing system makes the intermediate tracks on this angle of dip 29 degrees still more efficient, as in a large machine stope, for example, where packs are only 10ft. from the face, and a bench has to be blasted between the pack and the face. The quick clearing away of the broken ore is facilitated by means of small trucks run close to the face."

It is interesting to note in connection with this contribution to the *Journal* four years ago, that the whole question of waste packing was ignored when the discussion on the original paper was being replied to.

The question of waste or reef being used is surely a matter of underground conditions on the individual mines, and if waste rock can easily be obtained, either by waste sorting underground or by breaking into either foot or hanging wall, then when the packs are built they need not be again taken out, but if reef must be used, then by having, say, 50 per cent. reef packs and 50 per cent. waste packs, the reef could be easier reclaimed, and the waste packs would help to support the wall whilst this operation was in progress. It is interesting in this connection to notice that waste packing was systematically carried out twelve years ago at the Nigel Mine, and tram roads were laid right to the face. The reef being thin, enough waste rock was got to supply all that was required for the pack walls, and very little timber was used.

The whole question is not so much whether reef or waste be used in the packing as, broadly speaking, the acceptance of coal mining methods and applying them to Rand mining. This means working more on the wholesale principle than on the selective principle. In the early days naturally the selective principle was adopted, as costs were high, but as costs were reduced more ore could be mined profitably, and as mines got deeper larger areas were necessary and working tended gradually towards wholesale mining. Mr. G. A. Denny,* in a recent paper, advocated what may be described as the extreme of selective mining, even to the closing down of the poorer mines, so as to assist the richer ones by relieving labour and stores, but to my mind it is in the direction of wholesale mining that the future success of the Rand depends.

I was greatly interested in Mr. Cazalet's remarks regarding criticism and opposition by new comers and others who thought that much unnecessary material and labour was being wasted, as I had an experience about 15 years ago whilst mining a large rich gold reef in Rhodesia. The reef was about 30ft. wide and almost vertical, and in the oxidized zone for nearly 200 feet from the surface the walls were soft and friable. The upper portion of the mine had been laid out to work the reef by the caving method, somewhat like the method adopted at Kimberley, but it appeared to me that the reef, which was of hard quartz in large blocks, was not suitable for this method, and so work was begun at the bottom and the ore worked out in slices, and the excavated area filled in with waste surrounding timber cribs and ore passes. Naturally a large amount of timber was used, but the reef was all successfully mined right up through the ancient workings to the surface.

---

* *The Journal of the S.A. Institution of Engineers*, Vol. XI., No. 11, pp. 305-308.

* The *Journal of the S.A. Institution of Engineers*, Vol. XV., p. 180.

There was considerable criticism of this method by some of the officials, and at a mine near by, where their reef was also nearly vertical in talcose schist walls, the management criticised the method we were adopting, and called it simply wasting or burying timber. Incidentally, the management at that mine were Rand men. In the oxidized zone an attempt was made at that mine to work on the shrinkage method, and steel sets were placed in the drives underneath where stopes were commenced. In a few months, however, the steel sets were twisted and contorted and the walls squeezed in towards the reef, so that the mined ore became wedged and packed so tightly that it would not run to the boxholes, and very soon several of these stopes had to be abandoned altogether.

We had at our mine mostly coal miners from home, and it was simply the application of the longwall system of packing, adapted to a vertical reef, which enabled the miners to excavate all the ore without leaving any pillars.

On the Rand, in past years at any rate, any suggestion of coal mining methods was ignored as being altogether too elementary for gold mining, and I can recall a conversation I had with one of the examiners for the mine managers' certificate in the Transvaal, which illustrates this point. He was relating a few cases of answers given at a previous examination, and said one candidate was asked "How he would sink and equip a vertical shaft 1,000 feet deep, and," remarked the examiner, "he actually suggested sinking a circular shaft and lining it with brick."

The fact that probably this candidate was a North of England man, and more accustomed to circular shafts lined with brick, was not taken into consideration. It was not Rand practice, and therefore wrong. This conversation occurred a long time ago, when the theory of the "brains to the square inch" was more of the nature of a postulate than an axiom, so no reflection is cast on the present board of examiners, who no doubt fully realise that circular shafts, under certain conditions, are not without some merit.

I could give further examples from personal knowledge where the want of coal mining experience led to practices which were inefficient, such as having to discuss for fully three months the absurdity of turning the vertical shaft on to a reef dipping at only 15 degrees before the idea was finally abandoned. The shaft had been laid out for a bend, and the engine was capable of carrying a much greater length of rope, and these two reasons were used to justify making a compound shaft under these conditions. Skips, compound shafts, and ore bins, are peculiarly metal mining practice, and anything that differed from metal mining practice could not be considered. "Controlled weight," for instance, to assist in breaking the ore, has not so often to be considered by the metal miner, though it is a daily consideration by the coal miner. If my memory serves me rightly, Mr. Stuart Martin called attention to this several years ago, and stated that full advantage of this was not being taken by many of the mines on the Rand.

Mr. Cazalet has stated that there is considerable variation in the number of reefs worked, also in the thickness and dip of these reefs, even in the fifty miles of workable Rand formation; but in Scotland, between Ayrshire and Edinburgh, a distance of about fifty miles, there are coal seams, ironstone beds, and shale beds, successfully worked, varying from 12in. thick to nearly 12ft. thick, and from lying horizontal to nearly vertical in dip, and many modifications of the Longwall and Pillar and Stall methods of working are to be seen. As far back as 1895, Mr. R. T. Moore, of Glasgow, in discussing a paper on the banket formation of Johannesburg, said: "The Rand gold fields resembled very closely the Edinburgh coal field There, for a distance of

---

* Journal S.A.I.E., Vol. XV., p. 180.

ten miles along the western outcrop, the seams of coal, called 'edge seams,' lie at a dip of from 70 degrees to 85 degrees, and are worked at that inclination for 1,800 feet from the surface, and yet a mile back the upper seams of coal are found lying flat. The dip at the eastern outcrop is 1 in 5 and less." Of Fifeshire alone, Mr. Andrew Burt, in the paper previously referred to, says: "The seams of coal at present worked vary in thickness from 18 inches to about 20 feet. The system of working adopted is Longwall with its various modifications," and in summing up some of the advantages of the Longwall system says: "The whole available coal is wrought, the ventilation of the working places is much easier, and it is as safe, as economical, and as efficient as any of the other methods of working thick seams of mineral," and in December, 1908, at the Manchester Geological and Mining Society, Mr. Joseph Dickenson, speaking of the previous waste of small coal in South Wales, said: "In those days there were very few seams that were worked clean out, but in some of the thick seams, with Pillar and Stall work, the waste was enormous. The difficulty of getting the colliers to work Longwall in those thick seams was such that it was practically insurmountable. Now, however, that difficulty had been got over, most of the seams were being worked Longwall, and there was little or no waste taking place in the workings."

At St. Etienne Coal Field, in France, the seams and methods of working are described by Mr. Hugh Clarkston Annett in a paper read before the North of England Institute of Mining and Mechanical Engineers in December, 1908, from which it is seen that the coal seams vary from 4 feet to 80 feet in thickness, and dip at angles from 10 degrees to 90 degrees from the horizontal. Four methods of working are described, but whatever method is worked it is compulsory by law to systematically and completely fill up the excavated areas.

Rock is quarried on the surface, and sent down the mine for packing purposes, so that the four methods are more or less modifications of the Longwall system of working, in so far as all the coal is taken out as the face advances and no pillars are left in the workings.

It has often occurred to me why the cost of handling a ton of coal, which bulks more largely than a ton of ore, and therefore requires more truck capacity, should be so much less than the cost of handling a ton of ore in bringing it from the face to the surface.

The only explanation seems to be in the more systematic manner in which the haulage roads are driven, and the more wholesale manner in which the available area is worked. Consequently it appears that the nearer to wholesale mining one can get the more economical will be the cost of handling, and as time goes on the tendency on these fields certainly is towards wholesale mining. For this purpose the layout in the first instance must take haulage and ventilation into consideration, as it is practically and economically impossible to efficiently ventilate a mine if this provision is not made.

The first principle of ventilation is that there be two openings to every section, an intake and a return, and the return of one section should not join up with the intake of another section.

If this principle is fully realised it has not yet been acted upon by many mines of the Rand.

This is where the systematic packing of worked-out stopes is going to have a very beneficial effect, as separate intakes and returns can be made as stoping proceeds by means of these pack walls; but this is only one step in the right direction, and sections have yet to be arranged with ventilating currents entirely separate from each other.

In a recent report of the Sub-committee of the Association of Mine Managers of the Transvaal it is stated: "With the existing appliances it is an easy matter to get large volumes of air down a mine, but to ensure that throughout an extensive mine every individual shall be surrounded by a healthy atmosphere requires the mine to be laid out from the very beginning with this object in view," and later it states, "The system of putting a fan at every level to ensure that each shall receive its exact proportion of fresh air would have some advantages, providing the increased probability of short circuiting could be overcome."

It is just because mines are not laid out with a view to proper ventilation, and also because the stopes in many cases are not systematically packed where reef has been extracted, that short circuiting takes place, and although a mine has not been laid out originally to suit, much could be done in laying out future development in fresh ground.

If small auxiliary fans are used the air in many cases may only be oscillated back and forward in the same section.

What would happen in a fiery coal mine if this were done is too serious to contemplate, and yet while what actually does happen in many gold mines is not so dramatically drastic, it is none the less serious.

The dust which causes the great mortality amongst miners is the very finest dust, which is easily carried by an air current, and if this fine dust were treated as a noxious gas and taken out of the mine by efficient ventilation, instead of being allowed to accumulate in the workings, a better state of affairs would soon appear underground.

The suggestion, also contained in the foregoing report, "That fans should be stopped at blasting time for a short period to allow men to get out of the mine," though a good one under present conditions, should not be necessary under efficient conditions, as men should be able to get easily from the face into the intake airway, or at least away from the return airway.

If sufficient air were kept in circulation past every working place this fine dust produced by blasting would be carried out of the mine altogether.

With regard to this subject of ventilation, I would suggest that a simple anemometer (the simpler the better) be placed in the hands of every shift boss, and that he record periodically the average velocity of the air current at various points in his section, and in a few months more practical knowledge of the actual ventilating condition of the mines would be known than by any amount of air testing. Even if the readings were not very accurate, being taken by the same person in the same manner at the same places each time, they would be relatively correct, and any sudden changes caused by fresh connections being made would be noted, and the necessary steps to counteract these changes would be suggested.

I know that the dust sampling has shown that the average quantity of harmful dust in the air of the mines is much greater during the dry, cold winter months than during the moist, hot summer months; and it has been suggested that this is partly caused by increased ventilation stirring up the dust in the workings, and it is hinted that increased ventilation is therefore bad, but probably a little more attention to more efficient watering during these dry winter months might have a very beneficial effect; certainly the quantity of fresh air should not be curtailed.

In a paper read before this Institution some time ago on the construction of the Johannesburg Town Hall* an elaborate system of ventilation was fully explained, and surely if it is necessary to provide this for a large hall above ground where 2,000 to 3,000 people are to be only for a few hours at a time, it is still more necessary to provide a still more elaborate system of ventilation where an equal number of men are employed 3,000 to 4,000 feet under the ground for eight hours at a time.

Probably by using the term elaborate the idea is conveyed that the system is necessarily a costly one, but if proper forethought be taken in laying out the various sections, and in maintaining suitable pack walls, as described in Messrs. Smith and Selby's paper, the final result, in my opinion, will be a reduction in mining costs instead of an increase.

Certainly in many mines an ideal condition cannot be attained, but a very great improvement in present conditions would result, and still greater improvements would follow.

Ventilating currents underground, if not properly controlled, have sometimes a very erratic manner of behaviour. I have known quite a good current of air to travel in a certain direction for several months, and after a fresh connection had been made to suddenly turn round and flow in the reverse direction. This is where the anemometer in the hands of the shift boss would be so useful, as very often it is difficult to tell in which direction an air current is flowing unless at blasting time, when the direction of the smoke indicates this.

In June, 1906, Mr. George Farmer, in a paper on "Considerations of Deep Mining" to the Institution of Mining Engineers, says: "Ventilation will be needed to flow at higher velocities, because it is found that men can work in a high temperature with air at a high velocity better than in the same temperature, or even at a lower temperature, at a low velocity"; and adds: "The Longwall method of working it is quite likely will be universally adopted owing to its adaptability to a simple and adequate ventilation."

---

* W. Hawke — *The Journal of the S.A. Institution of Engineers*, Vol. XIV., p. 111.

As to earth tremors, it seems a natural inference to draw that these shocks are entirely due to subsidence or gravity. The strata overlying the Rand reefs are hard and brittle, and subsidence in the past has not taken place by bending gradually, but by frequent bursts of the rock at the area of greatest strain. When the first burst takes place the underground workings are filled up, and subsequent bursts may not further affect the mine, though the shock may be equally felt on the surface.

In December, 1908, Mr. William Hay, President of the Midland Counties Institution of Engineers, gave some very valuable statistics relative to surface subsidences where a 5ft. seam of coal was being worked at a depth of 1,600 feet by Longwall system in a regular manner. These statistics showed that although the surface actually sunk about 18 inches, the damage to certain buildings was caused by cracks or fissures in the magnesian limestone 60 to 80 feet thick, lying practically on the surface, and all other buildings escaped damage altogether. "At different periods during five years two distinct earth tremors were felt, both causing some alarm in the neighbourhood," and "these," he states, "were undoubtedly due to subsidence of the strata."

Then, Mr. Jonathan Piggford, the succeeding President, in contributing some notes and observations extending over 16 years, after giving details of certain damage done to some buildings, says: "Several cases of precisely similar nature have occurred at another colliery belonging to the same company, but in every instance where damage was done, and the foundations examined, it has been found that these open sand cracks in the limestone were the primary cause of the disturbance;" and adds, "The deductions to be drawn from these observations are, that at a depth of 600 feet, with a seam of 5 feet to 6 feet thick, the intervening strata being fairly well interspersed with rock bands, free from sand cracks or faults of any magnitude, and where the mode of working is Longwall, subsidences will be so regular and gradual as not to disturb to any appreciable extent the stability of buildings on the surface."

I have quoted rather freely from these past papers, because I think that the mining of the conglomerate beds on the Rand is so nearly akin to coal mining that the experience gained in other parts of the world should be made use of in determining the best method to be applied here, and I feel sure these two papers by Mr. Cazalet and Mr. Smith and the discussion thereon will lead to better conditions underground, greater safety to life and limb, and, what is also a very important matter, a reduction in actual mining costs.

A METHOD FOR FURTHER REDUCING CYANIDE AND ZINC CONSUMPTION.

By R. C. H. Cooke, F.C.S., A.I.M.M. (Lond.) (Member).

(Printed in Journal, August, 1917).

DISCUSSION

Mr. H. A. White *(Vice-President)*: This timely and useful paper deserves a thorough discussion, and it would be well if our members came forward with results obtained when reduction of cyanide strength was attempted at the beginning of the war. It would also be useful if some explanation were afforded of use of high cyanide strengths up to 0·25% KCN on certain mines. For example, I am informed that on two adjacent mines on the East Rand the difference in strength of cyanide used on the sand as strong wash is extraordinary—in one case 0·05% KCN is found sufficient while in the other 0·25% KCN is thought to be necessary. It may at once be stated that where solutions are maintained at a definite strength the difference in cyanide consumption is very much less than a comparison of the strongest solutions used would lead one to expect. It is also unfortunately true that the more scientific practice of adding a considerable portion of the cyanide required at the point where it can do most good, namely, at the head of the extractor boxes, has a disappointingly small effect on the total consumption. This procedure which is so strongly recommended by the author is one which I endorse the more readily, as I suggested a similar practice in June, 1910.* As the author ably points out this method if carried out systematically reduces considerably the difficulty of maintaining good precipitation and also helps to maintain the regularity of output of gold from the clean-up.

---

* See this *Journal*, Vol. X, p. 448.

I would also strongly support the author's suggestion to use any waste heat to increase temperature of sand solutions, and a single experiment on the large scale, performed some years ago, indicated that a reduction in strength of solution required could be effected in this manner without any increase in the residue value, though a companion experiment in reduction of solution strength without the addition of heat, resulted in increased loss of gold in the residue considerably beyond the value of possible saving in cyanide.

It may be well to point out that even at present prices a saving of 0·05 lb. of cyanide per ton, which is very difficult even with the most careful application of all published information, would be offset by an increase in residue value of 0·015 dwt. of gold, an amount well within the range of normal variations and not very far outside the limit of accuracy of sampling and assaying. It would also be well to point out that the strength of cyanide solution required for mere dissolution purposes cannot be reduced without limit, and that limits on various mines may be very different. As far as sand treatment goes, I know of no cases where it is necessary to have the calculated value of strongest solution used (allowing for residual moisture) greater than 0·05 KCN but have found that higher residues are usually obtained at half that strength, though economy in cyanide is quite small as so much more cyanide must be added to boxes to maintain precipitation. It must also be observed that though heating would probabaly be very beneficial in this direction if waste heat is available yet the more recent plants have replaced steam engines by electricity and so have no waste heat to spare.

I cannot leave the discussion of this paper without again expressing my appreciation of its usefulness and the desire that the subject matter should meet with a thorough discussion.

The meeting then terminated.

Review.

INTRODUCTION TO THE RARER ELEMENTS.

By Philip E. Browning, Ph.D.

4th Edition New York: John Wiley & Sons, London: Chapman & Hall. 1917
Pages x + 250. Price, 7s

This book, which was first published in 1903, has now reached a fourth edition, and this fact tends to prove that it has undoubtedly met a want. As the title indicates, and the author reiterates in his preface, it does not aim at an exhaustive description of the work done, but as a general brief survey of the field, accompanied by such experimental work as should serve as an introduction to the particular element chosen for investigation. Most of the elements are dealt with under the following headings, namely, discovery, occurrence, extraction, the preparation and properties of the element, the typical forms of its compounds and their characteristics, estimation, separation and experimental work. The difference between this and the previous editions is, briefly, that the work has been brought up to date by the incorporation of recent research and development. Ample references to the literature are given, which will enable those interested to follow up any of the subjects treated. Professor Boltwood has revised the section on the radio elements but no experimental work is given, since most of it being primarily of a physical nature would be out of place in a chemical text book. A short chapter is devoted to the rare gases of the atmosphere, the description of which has been abbreviated to such an extent as to render it of little value. The qualitative analysis section at the end of the work, based on the well known work of Prof. Noyes and his collaborators, is valuable, and might be extended with advantage. A brief sketch is also included of the technical applications of the rarer metals. The book is primarily intended for college students taking the ordinary courses of chemical instruction, and considering the length of time, which can be devoted in such a course to this work, we can have no hesitation in recommending this book, and the review questions given at the end will help to revise and consolidate the knowledge gained by its perusal and study.

J. A. W.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

The Determination of Chromium in Ferro chrome.—"Lack of uniformity in results reported by different laboratories led to a careful study of the methods used. Four volumetric methods were tried. In three cases the sample was first fused with Na_2O_2, and the Na_2CrO_4 thus formed was either treated with KI in acid solution, after the removal of the excess peroxide, and the liberated

I titrated with $Na_2S_2O_3$ or, in acid solution, a liberal quantity of ferrous sulphate was added and the excess titrated with $KMnO_4$ or $K_2Cr_2O_7$. In the fourth method the sample was ignited with Na_2CO_3 and MgO, the aqueous solution of the ignition product was acidified, treated with ferrous sulphate and titrated with permanganate. Satisfactory results were obtained only after fusion with Na_2O_2 and when the final titration was with $K_2Cr_2O_7$ or $Na_2S_2O_3$. By a number of different lines of attack, it was proved that in this way the results were not only consistent but accurate. The following procedure will give reliable results in about 1 hour. First pulverise the sample till it will all pass through a sieve with 2700 meshes to the sq. cm. Mix 0·5 gm. of the powder with 5 gm. or 6 gm. of Na_2O_2 in an Fe crucible of about 40 cc. capacity. Take hold of the crucible with tongs and heat it over a small flame for about 1 minute until the mass is liquid and then raise the temperature, while keeping the crucible in motion, and give it the full heat of the Bunsen flame for about 2 minutes. Allow the crucible to cool somewhat, then place it in a 1000 cc. beaker containing 350 cc. of water at 60-80° and cover with a watch glass. After the violent evolution of gas is over, boil carefully for 5 minutes to decompose the excess of peroxide. Bumping can be prevented by moving the beaker back and forth. Cool and transfer, with the aid of a funnel, to a 500 cc. calibrated flask. Make up to the mark with distilled water, mix thoroughly and filter through a plaited filter. Take exactly 100 cc. of the filtrate (=0·1 gm. of the sample) dilute it in an erlenmeyer to about 300 cc., add 1 gm. of KI and shake till the salt has all dissolved. Add 40 cc. HCl (sp. gr. 1.12), allow to stand 1 minute and titrate with 0·1 *N* $Na_2S_2O_3$ solution. The values should not differ by more than 0·3% from the truth."—W. Herzig, *Stahl u. Eisen*, *36*, 646-50 (1916).—*Chemical Abstracts*, May 10, 1917, pp. 1107-8. (J. G.)

The Chemical Evaluation of Chromic Acids and Alkali Dichromates.—"As a simple method for determining the purity of soluble chromate salts for technical use, S. recommends titrating the dichromates to normal chromates with 0·5 *N* KOH, either with phenolphthalein or without indicator; and the chromates to dichromates with 0·5 *N*. H_2SO_4 using congo red as indicator. The method can be used for mixtures of the two salts. Analyses show that results correct to within about 1% are obtained."—J. F. Sacher, *Farben-Ztg.*, *22*, 213 (1916).—*Chemical Abstracts*, May 10, 1917, p. 1112. (J. G.)

Soap as an Indicator in Volumetric Analysis —Titration of Solutions of Colouring Matters. "In the acidimetric or alkalimetric titration of solutions of colouring matters where the use of indicators is unsatisfactory, good results may be obtained by using soap as indicator. The soap solution is prepared by saponifying linseed oil with KOH solution and exactly neutralising with dilute acid; 1 cc. of soap solution is used for 100 cc. of the solution to be titrated. The production of a turbidity in the presence of free acid and disappearance of turbidity in presence of free alkali are sharp and rapid at ordinary temperature and in artificial light."—I. F. Sacher, *Seifenfabrikant*, *36*, 289-90; through *J. Soc. Chem. Ind.*, *35*, 1084 (1916).—Chemical Abstracts, May 10. 1917, p. 1112. (J. G.)

Volatility of Gold in Air and Other Gases. —"Gold was purified by a modification of the method of Kruss (*Ann. 237*, 274 (1887)) precipitated from de-silvered $AuCl_3$ solution by H_2O_2 and KOH according to Vanino and Seemann (*Ber. 32*, 1968 (1899)) and melted under borax. Experiments were conducted in a horizontal Heraeus furnace. In the final experiments the gold was in a chip of quartz tube which weighed 0·2—0·3 gm. Weighings were made on a delicate balance by means of a microscope. The gold, quartz chip and SiO_2 boat were weighed exactly before and after heating. The gas was led through the furnace at a pressure of 2—3 mm. Hg. For each temperature the gold was in the furnace exactly 30 minutes. In O_2, N_2, CO_2 and CO loss was observed only at the first melting, due to gas content of the freshly prepared gold. Otherwise no loss was detected between 1250° and 1400°. These results contradict T. Rose (*J. Chem. Soc.*, *63*, 714, (1893)). In H_2, 30 tests were made, some with purified gas from a cylinder others in gas obtained from pure Zn and H_2SO_4. Loss began at 1200° and increased with temperature and time of heating. Heated at each temperature for 25 minutes 400 mgm. were lost: at 1250°, 0·22 mgm.; at 1300°, 0·35 mgm.; at 1350°, 0·42 mgm.; at 1400°, 0·98 mgm. The curve volatility (ordinate)-temperature rises rapidly from 1350° on. The quartz chip, SiO_2 boat and heating tube were all coloured intense red while no colour was observed in any other gas. Gold could also be detected in the absorption liquid (H_2SO_4). Apparently above 1200° an unstable compound is formed, *e.g.*, Au_2H_2, in analogy with the partly volatile red compound. Cu_2H_2, observed by Leduc (*Compt. rend.*, *93*, 71 (1891))."—W. Mostowitsch and W. Pletneff, *J. Russ. Metall. Soc.*, *1915*, 410-31; through *Met. Chem. Eng.*, *16* 153-4. *Chemical Abstracts*, May 10, 1917, pp. 1104-5. (J. G.)

The Iodine Content of Stassfurt Sylvite and Carnallite.—*Detection of I*:—Dissolve 10 gm. of the salt in 200 cc. of H_2O, filter if necessary, transfer to a 300 cc. separating funnel having a narrow, drawn-out outlet tube (cf. *Z. angew. Chem. 28*, I, 495 (1915)), add 10 cc. of CCl_4, and shake. Add 10 drops of a 1% $NaNO_2$ solution and 10 drops of fuming HCl, shake vigorously for a few minutes. If the 10 gm. of salt contained 0·1 mgm. I the CCl_4 is coloured a distinct rose-red; on shaking for 15 minutes a colour is obtained with 0·05 mgm. I. If the I content is less than 0·05 mgm. the test is made as for I in sea water (cf. *C. A. 10*, 2674). *Determination of I*: (*a*) *Iodometrically*. A modification of a process previously reported (cf. *Z. angew. Chem. 28*, I, 496 (1915). Dissolve 5 gm. of the salt in 50 cc. of H_2O, filter, wash with 50 cc. of H_2O, transfer to a 200 cc. flask; add a little coarsely powdered pumice (from the tip of a knife blade), then 10 cc. of 0·1 *N* HCl and about 2 cc. of freshly prepared $Cl+H_2O$, boil vigorously 10 minutes. As a control dissolve 5 gm. of pure KCl and 0·015 gm. of KBr in 100 cc. of H_2O, and treat as above. To the cold solution add 5 cc. of 25% H_3PO_4 and 0·2 gm. of pure KI and set flask in a dark place for 10 minutes, then titrate the free I with 0·02 *N* $Na_2S_2O_3$ solution. The control should show very little or no free I. (*b*) *Colorimetrically*. (Cf. *C.A. 10*, 2674.) The various samples of sylvite examined contained in 1000 gm. from 0·0 to 73·1 mgm. of I present as KI, no KIO_3 being detected: carnallite in 1000 gm. from 0·0 to 5 mgm. of I present as $KI.MgI_2.6H_2O$. *Testing crude Br for I*: Dissolve 10 gm. of the Br in 1 litre of H_2O, add 10 cc. of *N* HCl and boil vigorously 10 minutes, cool, make up to 1 litre and test for HIO_3 by the As_2O_3 solution test given for the examination of sea water (cf. *C. A. 10*, 2674). Negative results obtained for the Br examined. A control test with 10 gm. of the crude Br and 0·05 mgm. I (added as KI) coloured the final portion (0·5 cc.) of CCl_4 a deep rose red. The assumption that the absence of I in the crude Br made from carnallite end lyes proves the Stassfurt K salts I-free is erroneous. A lye relatively rich in I may yield a Br free from I, as free Cl or Br oxidises the I to HIO_3 which remains in the residue after distillation of the Br., *e.g.*, in the control test above, the I was not volatilised."—L. W. WINKLER, *Z. angew. Chem.*, 29, I, 342-3 (1916; cf. *C. A. 10*, 867, 1491).—*Chemical Abstracts*, May 10, 1917, pp. 1106-7. (I. G.)

RAPID METHOD OF DETERMINING NICKEL AND COBALT IN ORES AND ALLOYS.—"Nickel and cobalt are precipitated from an ammoniacal solution by potassium iodide, as haxammine nickelous iodide, $[Ni(NH_3)_6]I_2$ and hexammine cobaltous iodide, $[Co(NH_3)_6]I_2$, respectively, and in the presence of excess of iodide (0·6 gm. KI per 0·1 gm. of nickel and cobalt) beyond that required for complete precipitation the precipitates are sufficiently insoluble for quantitative work. The volume of strong ammonia solution (sp. gr. 0·88) should be at least two-thirds of the total liquid, which should not be much in excess of 80 cc., and the required amount of potassium iodide in cold saturated solution should be added immediately after the ammonia to prevent oxidation of the cobalt. Since small amounts of nickel or cobalt (less than 2 mgm.) do not give a precipitate within 10 to 15 minutes the method is not suitable for the detection of traces of these metals. The crystalline precipitate which can be rapidly filtered off, without the use of a filter-pump, is washed with a solution of potassium iodide (10 gm. per litre) containing 800 cc. of ammonia solution. The washed precipitate is dissolved in hydrochloric acid, with the addition of sulphurous acid to remove the liberated iodine, the solution filtered, and the cobalt and nickel determined by the author's alkalimetric method. Ferrous salts in ammoniacal solution containing sufficient tartaric acid to prevent precipitation of hydroxide yield a white precipitate of hexammine ferrous iodide, $[Fe(NH_3)_6]I_2$, whilst ferric salts are not precipitated under these conditions. Hence, in the presence of excess of tartaric acid (about ten times the amount of iron present) cobalt and nickel may be separated in this way from iron by a single precipitation. Manganous salts yield a white pentammine manganous iodide, $[Mn(NH_3)_5]I_2$, which is more stable than the ferrous salt. Manganese is less readily precipitated than nickel or cobalt, but is liable to be carried down with the iodide precipitates of those metals. It is therefore advisable to dissolve the mixed iodide precipitate in a small excess of dilute acid, add sodium acetate in excess, and re-precipitate the nickel and cobalt with hydrogen sulphide. Copper is not precipitated under the conditions described (*i.e.*, in ammoniacal 1% potassium iodide solution), but with a higher concentration of iodide yields a blue crystalline tetrammine cupric iodide, $[Cu(NH_3)_4]I_2.H_2O$. In presence of nickel and cobalt, however, some precipitation of copper takes place simultaneously from weaker solutions. This copper may be separated by dissolving the mixed precipitate in dilute hydrochloric acid, when cuprous iodide is precipitated, with the liberation of iodine. The liquid is boiled, cooled, and filtered, the precipitate of cuprous iodide washed with cold water, and the cobalt and nickel determined in the filtrate. The copper may alternately be removed as cuprous thiocyanate prior to the precipitation of the cobalt and nickel, and the filtrate oxidised with nitric acid, evaporated nearly to dryness, and treated with tartaric acid, ammonia, and potassium iodide. Cadmium yields a white crystalline precipitate of tetrammine cadmium iodide, $[Cd(NH_3)_4]I_2$, and is co-precipitated with nickel and cobalt. In the rare cases when it is present in nickel and cobalt ores it may be separated by passing a current of hydrogen sulphide through a solution of the mixed iodide precipitate, faintly acidified with sulphuric acid. Zinc is not precipitated under the conditions of the determination. Barium salts are removed from ores as sulphate at the same time as the insoluble gangue. Soluble calcium salts do not interfere with the method, but if present in large quantity they might crystallise as tartrate and interfere with the separation of the cobalt. In such cases it is advisable to evaporate the solution of the ore with 1 cc. of strong sulphuric acid until fumes appear, then to add water and an equal volume of methylated spirit, and separate the anhydrous calcium sulphate. The precipitate is washed with 50% alcohol, and the filtrate and washings evaporated to about 5 cc. Magnesium has no influence on the results. Lead iodide is soluble in ammoniacal tartrate solution and its presence is negligible, but if lead is present in large amount it may be separated as sulphate. Mercuric salts yield a complex iodide which crystallises in needles, and is decomposed by water and acids leaving insoluble mercuric iodide. Silver forms a white precipitate which is decomposed by water or dilute acids, yielding the normal iodide, which can be separated by filtration. Aluminium, chromium, antimony, and bismuth do not interfere with the determination provided that sufficient tartaric acid has been added. Arsenic, oxidised by nitric acid into arsenic acid, does not influence the results. Should arsenic and magnesium be present together (*e.g.*, as in dolomite) a preliminary fusion of the ore with soda-sulphur or soda-nitre mixture would be necessary, since otherwise magnesium ammonium arsenate would be precipitated on the addition of tartaric acid and ammonia. Sulphides, unless decomposable by hydrochloric acid, are oxidised by nitric acid to sulphates, although in the separation of copper, as described above, some tetrammine cupric sulphate may be precipitated with the mixed iodide precipitate. This compound sulphate is converted into cuprous iodide when the mixed iodide precipitate is treated with hydrochloric acid, provided sufficient nickel or cobalt iodide is present: otherwise sufficient potassium iodide must be added to precipitate the whole of the copper. When an ore is treated with sulphuric acid as little as possible should be used, or most of the excess expelled as described in the case of calcium. Ammonium chloride in quantities exceeding 0·5 gm. has a slight solvent action upon the iodide precipitates, especially that of nickel. Hence if an ore has been decomposed with hydrochloric acid, the excess should be removed by boiling and the chlorides decomposed by evaporating the solution to a small volume with nitric acid, care being taken to avoid the separation of basic salts. The required amount of tartaric acid may then be added in the smallest quantity of hot water necessary to dissolve it, and the liquid cooled and treated with ammonia and potassium iodide."—W. R. Schoeller and A. R. Powell, *Analyst*, 1917, *42* 189-199.—*Journal of the Society of Chemical Industry*, July 16, 1917, p. 720. (A. W.)

METALLURGY.

Notes on Flotation—1916. —"Under the above title the author summarises results obtained by the Callow pneumatic flotation process at several mines, and compares the results with those by gravity concentration and with other flotation processes, such as that of the Minerals' Separation Co. He also replies to various criticisms of the process, and gives figures in support of the view that the Callow process compares favourably with those using mechanical agitation as regards labour and power costs.

The three flow-sheets at the Magma Copper Company's properties, where oxidised copper ore, sulphide copper ore and a zinc ore are treated, are discussed in considerable detail. The oxidised copper ore is stated to be treated on a commercial scale by a sulphide filming process. H_2S is obtained by heating sulphur and oil in a retort from which it passes through scrubbers to a gasholder. The pulp from a Hardinge mill to which the flotation oil has been added is pumped by a centrifugal pump to the first Callow cell and into this pump the gas is drawn. A hood and flue over the first flotation cell removes the excess of H_2S during flotation. The recovery obtained during several months trials lay between 70% and 80% of the copper content; the consumption of sulphur being from 2 lb. to 4 lb. per ton of feed. It is stated that the sulphide filming process is most encouraging for oxidised copper and lead ores, but not for zinc carbonates.

Other mining companies using the process are the Nevada Utah Corporation, who treat a complex ore, containing sulphides of zinc, lead and iron, the Walker Mining Company, who recover 90% of the copper content from an ore containing much magnetite; the presence of which makes gravity concentration unsuccessful. The process has also been installed at Cobalt, Ontario, and it is stated that the flotation tailing is from 1 to 1½ oz. per ton lower in silver than that from cyaniding. The disposal of the concentrate is the chief difficulty on account of high freight charges to the smelters. Experiments have indicated that the Holt-Dern chloridising roast may be the best method of treatment.

In a paragraph on the handling of flotation concentrate the author states that in recent plants intermittent filtration has been installed, continuous filtration not having given satisfactory results."—J. M. Callow.—*Bulletin of the American Inst. of Mining Engineers*, February, 1917, pp. 245-275. (H. R. A.)

Determination of the Capacities of Slime Thickening Vats. "In a lengthy paper the author gives the results of investigations carried out at El Tigre, Mexico, on the settling rates of slime, and the factors on which the rate depends. His results confirm those obtained by Coe and Clevenger* on the same subject. It is stated that by carrying out laboratory settling tests data can be obtained sufficiently accurate for application to the design of settling equipment on a rational basis.

The term 'natural slime' is used to denote finely divided particles of such minerals as kaolin, talc etc. and the word 'slime' is empirically defined as all particles which will remain suspended for five minutes in a 100 : 1 mixture of fresh water and ground ore at 60° F.; this covers all 'natural slime' and a considerable portion of very fine sand. In a footnote it is stated that this fine sand has little effect on settling rates which depend chiefly on the proportion of natural slime.

Another term used is 'critical dilution.' Above critical dilution the rate of settling depends on the flocculation of the slime particles and the degree of flocculation varies with the temperature and the concentration of electrolytes, *e.g.*, lime. Below critical dilution the flocs are in contact and channels form in the settled pulp through which water is eliminated. Above critical delution the term 'free settling zone' is used while below it, is referred to as the 'thickening zone.' Settling rates in the free settling zone depend simply on the settling area and not on the depth of pulp, while in the thickening zone the settling rate depends both on area and pulp depth. An interesting point which has also been noted by Coe and Clevenger is that when settling has apparently ceased further settling may be obtained by decanting the clear liquid and agitating the remaining pulp.

The laboratory determinations which are required are the settling rates above and below critical dilution, and details of laboratory methods are given.

The importance of conducting the laboratory tests under conditions of temperature, dilution, concentration of electrolytes, etc., which will obtain in practice is emphasised.

The empirical formulae used in calculating the settling capacity required are :—

(1) For area : $\text{Area} = \dfrac{1{\cdot}34(F-D)}{S}$

where the area is given in square feet per ton of dry pulp settled daily.

F = ratio of liquid to solid of the diluted pulp or feed.

D = ratio of liquid to solid of the discharge.

S = the settling rate in the free settling zone (determined by laboratory tests).

The factor 1·34 is for the reduction of the quantity of water eliminated from cubic feet per hour to tons per day.

(2) For Depth :

$$\text{Depth (in feet)} = \frac{1{\cdot}34(C-D)}{A \times T}$$

where C = ratio of liquid to solid at critical dilution

D = ratio of liquid to solid of discharge.

A = the settling area as determined by (1).

T = average settling rate per foot depth of pulp from dilution C to dilution D. (Determined by laboratory test.)

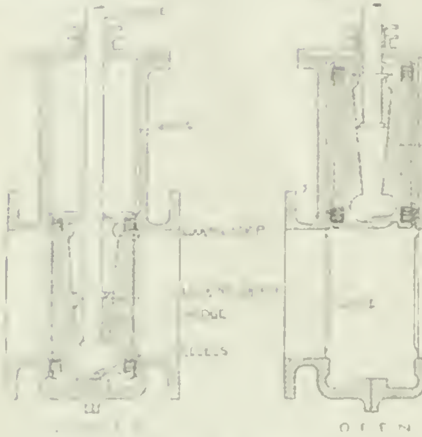
In cases where area and depth are fixed these formulae may be used as an aid in determining the most suitable dilution of feed and discharge. A graphical method of solving settling problems when interdependent settling operations have to be considered is shown. Graphs showing the

---

*Bulletin A.I.M.E., March, 917, p. 597.

[illegible] of temperature and concentration [illegible] are given.—[illegible] *Bulletin of the American Institute of Mining Engineers*, March, 1917, pp. 353-74. (H. R. A.)

VALVES FOR SLIME CIRCUITS.—In the *Monthly Journal* of the Chamber of Mines of West Australia, Mr. Thomas B. Stevens gives a review of many recent improvements in cyanide practice introduced at the West Australian mines. We extract herewith his description of a new valve for use in the pipes conveying the pulp.



Shaw's Valve for Slime Circuit.

In the early plants considerable trouble was caused by wear of the gates and seats of the filling and emptying valves, especially when dealing with sandy pulp, such as is frequently met with in the so-called all-sliming process. Not only was the renewal of the valves a constant expense, but serious amounts of dissolved gold were often discharged with the residue, owing to the gold-bearing pulp leaking into the wash water. In closing the ordinary type of full-way valve, the gate slides over the seat so that any sand which has accumulated around the gate causes a powerful abrasive action, and it is only a short time before a small leak is developed, which is rapidly enlarged by the scouring action of the pulp. It follows, therefore, that a satisfactory valve must not even leak a small amount. A valve which is particularly suitable for this class of work has been introduced by Edward Shaw, of the Oroya Links mine, Kalgoorlie. Mr. Shaw has greatly reduced the possibility of wear and leakage by fitting the gate of the valve with a renewable fibrous wearing ring, so that no metal-to-metal joint is made; by means of an ingenious design of the closing wedge, he also makes it impossible for the gate to touch the seat until it is in the correct position for tightening. For the convenience of manufacture, the trunk is made in two halves, which are flanged together. The gate is a double-seated one, and in each half of it a groove of dovetailed section is turned, into which the packing ring is fitted. The most satisfactory material for the rings has been found to be hard-woven hydraulic packing, which should be placed in the groove with the edges of the layers exposed. If put in with the layers flat, the outer plies of cotton are likely to peel off. The life of the rings is from six to twelve months, when used in a plant which puts through as many as twelve filter charges a day. The gates are closed by a wedge, which is also made in two parts, and is carried on collars turned on the spindle. On each side of the upper part of the wedge a groove is cut, called a locking groove, which fits over locking strips which are cast inside the gates; these strips and grooves are important details in the satisfactory working of the valve.

The operation of the valve is as follows: When starting to open, the spindle and wedge are raised and the gates are released from the seats, after which the wedge rides over the locking strips. It is not until the wedge touches the top of the inside of the gates that they start to rise, and as soon as they do start they are at the same time forced inwards by the guides in the trunk, which are flushed with the seat, so that any rubbing action on the packed face is prevented. Raised flats are provided on the corner of each gate to ride on the guide strips. On starting to close, the gates will be up in the trunk and locked to the wedge by means of the locking strips, so that the wedge and gates descend together; it is not until the correct position for tightening the gates is reached that the raised flats on them can fall into recesses provided in the guide strips so as to free the wedge and allow it to fall relative to the gates so as to expand them. To give satisfactory service, valves of this kind must be set vertically, as otherwise the gates will bind in the guides. At the same time, it must be remembered that all kinds of gate valves are preferably set in this position, and in the design of pipe arrangements thought given to this detail is amply repaid by the subsequent ease of operation and freedom from repairs. That the Shaw type of valve is a commercial success, is proved by the fact that in one plant over thirty of them varying in diameter from 4 to 12 inches have been in constant use for over two years, and have needed no renewals except that of the packing rings."—T. B. STEVENS, *Mining Magazine*, April, 1917, p. 222. (E. M. W.)

BISMUTH AND ITS USES AND MARKETS.—"Numerous useful alloys are made by fusing bismuth with other metals, such as copper, tin, lead, and antimony. A small amount added to copper makes this metal red-short, or brittle when heated, and an alloy made by melting one part of copper to two parts of bismuth expands considerably on solidification, while one part of copper fused with four parts of bismuth produces a red crystalline alloy. Small quantities added to lead give toughness without brittleness, and two parts of bismuth with three of lead has ten times the hardness and twenty times the tenacity of lead, while two parts of lead and one of bismuth makes a very fusible and ductile alloy. Antimony fused with bismuth produces an alloy which expands when changing from a molten to a solid state, and equal quantities of both in an alloy produces a greater expansion than any other metal on solidification. Bismuth with tin forms alloys which are very sonorous, and to produce this effect in a marked degree some of the many pewter and bell metals are made with bismuth as part of their composition. One part of bismuth to 24 of tin forms a malleable metal, which becomes brittle as the amount of bismuth is increased. Mercury is capable of absorbing a large quantity of bismuth in the formation of amalgams. Two of mercury to one part of bismuth forms a pasty mass, while with four parts of mercury the amalgam is in a liquid state. In the latter condition the amalgam is used in silvering both mirrors and the interior of vacuum flasks, although another alloy containing two parts of mercury and one each of bismuth, lead, and tin is used for the same purpose.

Bismuth is alloyed with two or more suitable metals to produce expansion when cooling down to a solid state, and which at the same time should be an easily fusible composition, the principal metals used in producing these two effects being lead and tin, with zinc, antimony, cadmium, and mercury as accessory constituents. In making solders the melting-point can be lowered if bismuth is alloyed with them, and soldering can be effected under boiling water if the right proportion, as shown in the table, is present.

	Bismuth M.P. 522°	Lead M.P. 621·1°	Copper M.P. 1981·3°	Tin M.P. 449·4	Cadmium M.P. 609·6°	Mercury M.P. 37·7°	Antimony M.P. 1166°	M. Point of Alloy, F.
Charpy's eutectic ..	8	5	...	2½	...	...	...	204
Newton's metal ..	8	5	...	3	...	...	...	201
D'Arcet's metal ..	8	4	..	4	...	...	...	199
Rose's metal ..	8	8	..	3	...		..	174°
Onion's mercuric ...	8	5	...	3	...	1½	...	170
Lipowitz's metal ..	8	5	...	2	1			150
Lipowitz's mercuric	8	4	...	2	2	1	..	143
Wood's metal ..	7½	4	...	2	2	...		140°
Guthrie's eutectic...	8	3	...	3	2½	...	...	very fusible
D'Arcet's mercuric.	8	4	..	4	..	20	...	113

Fusible Bismuth Alloys.

(Fusible below the boiling point of water 212° F.)

The variations in expansion and contraction of bismuth alloys indicate that in making castings it is better, when convenient, to allow the metal to cool to a semi-fluid condition and to press instead of pour the metal into the moulds, as then it is nearing its minimum contraction. Stereotype metal and other metals used in printing are only occasionally made up with bismuth as one of the constituents, but where rough usage is expected, or where firmness and sharpness is specially desired, no other metal produces these qualities so effectively as bismuth.

Bismuth is useful in the processes of steel tempering. The exact degree of heat required for the purpose can be fixed automatically by using baths of molten alloys containing bismuth, which can be made up of varying proportions and giving fixed melting points.

As stated already, the presence of bismuth in an alloy gives low fusibility combined with hardness and sharp definition. The addition of cadmium to the bismuth-tin-lead series further lowers the fusing point, while the addition of mercury brings the temperature of fusion down to its lowest limits.

Safety plugs for boilers are made of an alloy of which bismuth is one of the constituents. The automatic sprinklers or fire extinguishers placed in the ceilings of buildings are also made of a bismuth composition and are set in action when material in a room takes fire, the rise in temperature immediately melting the easily fusible bismuth plugs and causing jets of water to play all over the room.

Electric fuses are sometimes made of a bismuth alloy, and are so constructed that if too great a charge of current is passed through them the easily fusible wire melts. This causes a disconnection and prevents any damage to the instruments or appliances within the circuit.

Bismuth is extremely diamagnetic, that is opposed to magnetic influence. Antimony is another diamagnetic metal, and with bismuth forms the couple of a delicate thermopile, an instrument used for measuring by thermo-electric force, indicated by a galvanometer, extremely minute changes in the heat of metals.

Bismuth bronzes suitable for spoons, jugs, teapots, etc., are alloys made up of a number of metals, and are said to be unoxidisable, to keep a good colour, and to be easily polished. Two such bronzes are of the following composition, respectively: (1) Copper, 25 parts; nickel, 24; antimony, 50; bismuth, 1; (2) copper, 69; nickel, 10; tin, 15; zinc, 20; aluminium, 1; bismuth, 1.

Bismuth subnitrate is used in surgical operations, in porcelain painting, as a medicine, and as a cosmetic. In medicine the carbonate is used much more than the subnitrate as it is very easily assimilated. The oxychloride of bismuth as a medicine is of special use as a preliminary to surgical operations on the stomach. Four ounces of this is taken and assimilated, after which the stomach and intestines are photographed by X rays, the whole of the outline of these digestive organs, and their defects being clearly defined as a result of the opacity of the bismuth to these rays. Bismuth salicylate, gallate, lactate, and other organic compounds are used as medicine and in surgical operations, but the demand for them is much smaller than that for the carbonate, subnitrate, and the oxychloride.

The oxide is used in porcelain painting and also in glass staining, the object of its introduction and also that of the subnitrate being to prevent certain substances producing colour which otherwise are useful fluxes. In gilding porcelain the oxide or the subnitrate is mixed with 15 times its weight of gold, applied with a brush, and then fired. The subnitrate gives a colourless but iridescent glaze to porcelain and produces a yellow glaze when mixed with chromic oxide. The addition of 5% of gold to the oxide makes a good copper-red glaze mixture, which has also the quality of producing a golden lustre by reflected light. With less gold the colour may be varied, and beautiful blue and violet shades can be produced by other proportions and manipulations of the same ingredients. In porcelain painting and enamelling the bismuth compounds may be generally used as a flux for increasing the fusibility of other colouring oxides, and therefore become a vehicle for the oxides of manganese, chromium, and copper. Mixed with the oxide of antimony the subnitrate forms Merimee's antimony yellow, which is a good body pigment, and quite permanent.

Selling prices of metallic bismuth in London during the last twelve years are given in the table, which indicates that the prices were lowest in 1906 and reached their maximum in 1916. In the United States at the beginning of 1915 the metal was quoted at 11s. 6d. per lb., and at the latter end of the year at 10s. 8d. per lb. [The quotation in England during 1915 and 1916 relates chiefly to the purchase of ore; the distribution of the metal and compounds is in the hands of the Government.]

Bismuth Prices in London.

Year	per lb. s. d.	Year	per lb. s. d.	Year	per lb. s. d.
1905	9 0	1909	6 6	1913	7 6
1906	5 0	1910	7 6	1914	10 0
1907	8 0	1911	7 6	1915	10 0
1908	6 6	1912	7 6	1916	11 0

With regard to undesirable constituents of bismuth ores and their effect on the price of the ores, we quote the following paragraph in Mr. Dunstan's report:

"Arsenic is often associated with bismuth ores, and traces are generally present in crude metal. The removal of the impurity is said to be effected by subjecting the ore or metal to a dull red heat, at a temperature of 510-520° F., in a furnace under cover of charcoal. In pharmaceutical preparations this element must be eliminated, the British Pharmacopoeia standard allowing not more than two parts in 1,000,000 in the carbonate and subnitrate. Tellurium is a very injurious impurity in bismuth, and the crystalline structure of the metal is completely changed if 0·50% is present. Antimony is separated from bismuth by roasting it at a temperature of 350° F., the two forming an alloy which floats on the surface of the charge, and which can be skimmed off. Copper can be removed from molten bismuth, provided oxidisable metals are first removed, by introducing bismuth sulphide. This reacts with the metallic copper to form a matte which comes to the surface of the charge. Lead is removed from molten bismuth in Pattinson pots, the lead-bismuth alloy remaining molten while the pure bismuth forms crystals, and as such is removed."—B. Dunstan, *Queensland Government Mining Journal.—Mining Magazine*, April, 1917, pp. 218-219. (E. M. W.)

The Hybinette Nickel Process.—"The Ontario Nickel Commission's report describes the Hybinette nickel-refining process, which is to be used by the British American Nickel Corporation at the Murray mine, Sudbury. The copper-nickel matte, containing about 17% nickel, 33% copper, and 20% sulphur, with usually less than 0·1% cobalt, is granulated and roasted. It is then leached with a 10% solution of sulphuric acid to dissolve the greater part of the copper. The residue is melted and cast into anodes. The electrolyte used carries 15 gm. of nickel and from 3 mgm. to 5 mgm. of copper per litre, and is supplied by rubber tubes to the cathode diaphragms. After circulation it has from 2 gm. to 3 gm. of copper per litre, and is passed over waste anodes which deposit the copper and re-supply nickel to the solution. The action of the anodes is analogous to that of pig iron in precipitating cement copper, except that the copper is deposited by nickel instead of by iron. The solutions never have to be rejected, as they are sufficiently purified by the cementation. Waste fragments, after the cement copper has been brushed off, are crushed, roasted, leached with 10% sulphuric acid to dissolve more copper, and the residues are melted into anodes and re-electrolysed. The anodes for the nickel department are enclosed in special canvas bags stated to last 18 months. Paper diaphragms supported by common canvas at times have been substituted and have lasted 12 months. The cathodes are of iron treated with a wash of powdered graphite. The nickel is deposited on both sides of the cathode plate. These plates are arranged in parallel. The voltage is from 3 to 4 volts per vat, according to current density, which varies from 8 to 10 amperes per square foot. The deposition of the nickel takes about 15 days, and the sheets stripped from the cathodes weigh 20 lb. to 30 lb. each. They are about ¼ in. thick, and have the usual corrugated warty appearance, but the stalactitic growths are dense and give no trouble through short-circuiting. The sheets are washed in weak sulphuric acid to remove basic salts, are dried, and cut into 2 by 3 in. strips for market. The metal is guaranteed 99% pure, with usually no more than 0·03% copper. The precious metals accumulate in the anode slime, which is re-melted into anodes and separately electrolysed, the final slime being caked, dried, and sold for its precious-metal content. This process is carried out in Norway on matte from Evje and Ringerike, where power costs about $13.50 per horse-power year. The ore treated averages 1·6% nickel and 0·9% copper. The copper produced averages 99·72 fine."—From Report of the Ontario Nickel Commission in *The Mining Magazine*, June, 1917, p. 229. (H. R. A.)

Abstracts of Patent Applications.

368.17. Sten. Rudberg. Improvements in rock drilling apparatus. 23.6.17.

This application refers to a rock drilling machine provided with two or more pistons which are concentric with one another, and so arranged to deliver alternate blows upon the tool or anvil block abutting against the tool.

385.17. Jean Zwicky. Improvements in pumps and compressors. 6.7.17.

This application refers to improvements in pumps or compressors, that is in the particular arrangement of a double cylinder pump or compressor in which the valves for both cylinders are contained in a single valve casing between the cylinders, *i.e.*, the cylinders are single, acting with the outer ends open. The particular application is for valves of the ring or disc shape made of flexible material.

Other claims are for simple modifications of the main claim with regard to the construction of the valve chambers.

Changes of Address.

McCormick, A. R., *t/o* Johannesburg; Elands Drift, P.O. Ross Hill.

Fry, A. T., *t/o* Broken Hill; c/o Mt. Lyell M. and R. Co., Ltd., Collins House, Melbourne, N.S.W.

Fergusson, J., *t/o* High Wycombe, England; P.O. Box 1290, Johannesburg.

Andrews, A. A., *t/o* Barberton; Maid of De Kaap Mine, P.O. Consort Mine.

Fraser, C. G., *t/o* Glen Wills, Victoria; Story's Creek, Avoca, Tasmania.

APR 1 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII NOVEMBER 1917. No. 5.

Proceedings
AT
Ordinary General Meeting, November 17, 1917.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building on Saturday, the 17th November, 1917, Mr. G. Hildick-Smith (President) in the chair. There were also present:—

16 Members.—Messrs. H. A. White, A. Whitby, J. Chilton, J. Gray, F. W. Watson, E. M. Weston, W. A. Caldecott, Prof. G. H. Stanley (Members of Council), H. D. Bell, R. C. H. Cooke, A. King, G. Melvill, S. Newton, J. J. R. Smythe.

3 Associates.—Messrs. O. A. Gerber, H. Ward and J. A. Woodburn.

6 Visitors, including Mr. H. Warington Smyth, Mr. A. Baguley and Fred Rowland (Secretary).

MINUTES.

The President: As we had no quorum at the October meeting, we have to take the Minutes of the September meeting to-night.

The Minutes of the Ordinary General Meeting, held on the 15th September, 1917, as recorded in the September *Journal*, were then confirmed.

ELECTION OF NEW MEMBERS.

Messrs. H. A. White and A. Whitby were elected scrutineers, and after their scrutiny of the ballot papers, the President declared the following gentlemen unanimously elected to membership.

DANIEL, J., Government Gold Mining Areas, Ltd., P.O. Box 28, Brakpan. Surveyor.

FERGUSON, DONALD MEREDITH, Jupiter G.M. Co., Ltd., P.O. Box 27, Germiston.

HESLOP, WILLIAM TAYLOR, St. George's Colliery, Hatting Spruit, Natal. General Manager.

KRYNAUW, A. H., East Rand Proprietary Mines, Ltd., P.O. Box 57, East Rand. Section Manager.

RAYMOND, ROSSITER M., Santa Rosa Mining Co., New York, Mining Engineer.

STEELS, SIDNEY H., Village Main Reef G.M. Co., Ltd., P.O. Box 1091, Johannesburg. Reduction Manager.

THORP, M. J., Consolidated Main Reef Mines, Ltd., P.O. Box 2, Maraisburg. Mining Engineer.

TUCKER, GEORGE, Geldenhuis Deep, Ltd., P.O. Box 54, Cleveland. Manager.

The Secretary: The following Associates have been admitted by the Council:—

ANDREWS, ERNEST THOMAS EDWARD, Maid of the Mist Mine, Louw's Creek. Mine Manager.

ELLIOTT, EDWARD WILLIAM MACLEOD, Geduld Proprietary Mines, Ltd., P.O. Box 41, Springs. Mine Captain.

ROBINSON, DENHAM RALPH, 23, Esselen Street, Hospital Hill, Johannesburg. Mining Engineer.

RAILTON, RALPH, Dynamite Factory, Modderfontein. Laboratory Assistant.

GENERAL BUSINESS.

The Secretary: Mr. Morrisby has sent us a letter, in answer to a letter he wrote to the Deputy Commissioner of Kolar, on the question of covering cyanide dumps. The latter referred the letter to Mr. Gifford, Superintendent of the Champion Reef Gold Mining Company—who, by the way, is one of our members. This is Mr. Gifford's comment:

Mr. H. J. Gifford *(Member)*: I regret I can give no information regarding any vegetation which will grow on these sand dumps, as though we have experimented with several hardy creepers we found none which served the purpose. We have, however, been very successful in entirely preventing any blowing sand, even during the heaviest monsoon, by spraying the sand immediately after it is discharged, with diluted slime from our Butters' filter plant. This serves very well if the spraying is done daily, as in the case of discharge of current sand, but where a portion of a dump is finished with, and it is not convenient to spray it daily, we form shallow slime dams at convenient points at the foot and on top of the dump, and from these plaster the sides of the dump by hand for a thickness of 4 in. or 5 in. With our particular slime, carrying a little lime and magnesia, such a covering gets quite hard and stands the heaviest winds. The top of the dump is similarly covered by allowing slime to run over it until it is coated for several inches in depth. Our only trouble with an impermeable dump of this sort has been in getting rid of the amount of rainwater which collects on such a large surface on the top of the dump, and to do this and avoid causing big wash outs in the side of the dump, we have had to build rough timber and stone drains of large section from top to bottom, and to so arrange the slime covering on top with slight inclinations to direct the water towards the drains. I do not know if the slime from the banket is as viscous as ours, but we have found the addition of a little lime very useful for hardening or setting the slime, and with the covering above described we have on this mine quite abolished the sand nuisance.

The President: Mr. Gifford's remarks are very interesting and opportune, as the local Inspectors of Mines have instructions to strictly enforce Regulation No. 158 (27), which refers to the spraying of tailing dumps to prevent the dissemination of dust. With a mixture of mud and sand it may be possible eventually to grow some species of plants on the tailing dumps.

ASSAYERS' CERTIFICATES.

Mr. F. W. Watson *(Member of Council)*: I wish to bring up a matter concerning the Mining Regulations regarding the Assayers' Certificates. It says in the Regulations that the Commission of Examiners shall consist of:—

> "The Government Mining Chemist or a Government Analyst, who shall be chairman, an analytical chemist and a metallurgist, of whom at least one shall be engaged in academic work, and two mine assayers, of whom one shall be actually engaged in assay work on a mine, and who shall, *within three months of the coming into force of this Regulation*, be holders of Assayers' Certificates."

I wish to discuss the last clause beginning "within three months." I understand that the Commission, as at present constituted, complies with this Regulation, but my argument is this. Supposing one of these two assayers who have been appointed were to leave the Witwatersrand, could the Government Mining Engineer, under these Regulations, appoint an assayer who has obtained this certificate within the stipulated time? I know of one assayer who applied in June and did not get the form of application until last month. This Regulation was issued on the 30th May. So I consider if the Government Mining Engineer under these Regulations had to appoint another assayer, he would not have one qualified to fill the post. I think the three months' qualification is an error or oversight, and is a matter worthy of discussion at the meeting. Perhaps someone can give an explanation, otherwise I will move that our Secretary be asked to draw the attention of the Government Mining Engineer to the matter.

Mr. A. Whitby *(Vice-President)*: I would like to ask if any notices have been sent to the assayers and qualified chemists, calling upon them to register?

Mr. Jas. Gray *(Member of Council)*: Such a notice was published in the *Government Gazette* a fortnight ago.

Mr. A. Whitby: Yes; but how are we going to work? Have we to send in our qualifications?

Mr. Jas. Gray: The notice invited applications from those qualified. I do not think it likely that personal notices would be issued by the Mines Department.

Mr. John Watson *(Member of Council)*: I should like to reply to my friend, Mr. F. W. Watson. The amended regulations, including certification of assayers, were first published in the supplement to the Government Gazette of 1st June. I sent in my application for an assayer's certificate (accompanied by the required documentary evidence) well within the three months, and I think I am right in saying that at least 20 or 30 other assayers also applied within the three months. There has been some delay in the Government Printing Department at Pretoria—perhaps they are short-handed on account of the war; but I received a type-written notice, within the three months, that my service certificate had been granted. This particular regulation was framed to start the Board of Examiners, and, once it is started, there should be no difficulty. These regulations are not like the laws of the Medes and Persians, which could not be altered. Some of these mining regulations are amended every few years, and probably the wording of this particular clause will be altered ere long.

Mr. F. W. Watson *(Member of Council)*: The point I wish to emphasize is that the Regulations do not state that the assayers shall have applied for forms of applications. They must be *holders* of certificates within three months. I think the stipulation of three months is an oversight.

Mr. Jas. Gray: I do not think so. I think it was merely to start the thing going. The regulations are revised every second or third year and, once the thing is started, the regulation, no doubt, will be altered to meet the case. What I suggest is that the matter be referred by our Secretary to competent legal opinion. If it is an oversight, I have no doubt the point can be met as has been done before.

Mr. H. A. White *(Vice-President)*: I think it is an important point, because the constitution of the Board itself is involved; it cannot be completed without the inclusion of two assayers, who have to be appointed by the old Board. So I think it would be well if our Secretary were to take advice on the matter and have the Government approached.

Mr. Jas. Gray: The board was completed before the three months had expired.

Mr. F. W. Watson *(Member of Council)*: That is not my point. We all know well enough that the population of the Rand is a moving one. Supposing one of these two assayers were to leave the Witwatersrand, the Commission is then minus an assayer, and the Government Mining Engineer would not be able to appoint a man who had his certificate within three months.

Mr. Jas. Gray: I take it that an application sent in for an application form before they were ready would count.

The President: We had, I think, a letter from the Government Mining Engineer, asking us to nominate one of the members for the Board.

The Secretary: We made certain recommendations.

The President: I think the point is, as Mr. Watson says, that the assayers who applied for their certificates within three months of the coming into force of the Regulations, will be assumed to have received their certificates, and members of the Board will be chosen from amongst them.

The President: It is proposed by Mr. Gray that this matter should be referred to the Council, and, in the meantime, the Secretary be asked to obtain our Hon. Solicitor's opinion on the matter.

Mr. H. A. White *(Vice-President)*: I second that.

The proposal was agreed to.

OXY-ACETYLENE PROCESS AND THE RE-MAKING OF SHOVELS.

Mr. E. M. Weston *(Member of Council)*: I notice in the railway workshops in Australia they claim to be re-making shovels, at a cost of 3d. to 4d. each, welding on pieces to the blade with the oxy-acetylene process. If we are able to do anything in that line here,—there is a very large opening for private enterprise, or for the mines to equip a central plant. I just put this forward as a suggestion.

The President: We have to thank Mr. Weston for the suggestion, which will, I am sure, receive consideration from those interested in this particular matter.

Mr. Baguley will now submit a paper dealing with Fertilizers, a subject of great importance at this time.

FERTILIZERS.

By Allan Baguley, B.Sc., F.I.C.

The increased consumption of food owing to the widespread condition of war and the accompanying inevitable waste, demand as their corollary increased production. The disorganisation of the farming industry, due to the reduced supply of labour, and the difficulty of obtaining necessary machinery and fertilizers make increased production only more imperative. People, generally, will rejoice to see the staple articles of food in abundance, if only for the reason that the engineers of artificial dearth will thereby find their difficulties greater.

There is need for recognition of the fact that farming properly carried out is capable of affording exercise to the greatest ability ever possessed by man, and that, in spite of its strenuousness, and the constancy of its demand for attention and oversight it is a very pleasant and healthy occupation. Everybody ought to know something about the production of food, about the difficulty and arduousness of turning out wheat and milk, the source of bread and cheese, the staff of life, at a profit. There would then be greater sympathy between town and country populations. There is an all too general fighting shy of hard work, whether of head or hand that is especially notable in the practice of agriculture. The easiest methods of carrying out work are after all not adopted. There is very little evidence of prescience or thought in the matter of adapting science to the needs of the time. The condition arises from the exhausting nature of the farmer's toil and from lack of knowledge on the part of teachers in the science and art of agriculture. There is extraordinary need at the present time for the carrying out of research by scientific men, bearing directly on improved methods of producing food. A considerable body of knowledge has been acquired, but a new problem usually requires new knowledge for its solution, and there are many new problems to-day.

In advocating the necessity for increased production we must not forget that our agriculturists are first of all business men. If wheat, for instance, is not so profitable a crop as mealies in a particular case, we must not recommend the growth of wheat, let the imports be what they may. We have to recognise that wheat is a precarious crop in many parts of this sub-continent. The same is true to some extent with other crops. Oil seeds are often mentioned, but they are sometimes not adapted for much of the territory in question. We must urge suitability and profit as well as necessity.

One of the necessities to improve production is fertilizers. Another, is knowledge in their application that they may be rightly used. The need for increased production and fertilizers is apparent on several other counts. For example, there is the appreciating value of land. The price of land in South Africa is increasing. Good land in parts of the Transvaal and the Free State is worth £5 an acre to-day, and will be more. Increased production and fertilizers are required to make this greater value profitable.

Again, any expense in the way of conserving water, by dams and its distribution by water furrows, or in effecting drainage, adds to the value of the land, and has to be made good by increased production. Then there is the question of closer settlement, and consequent subdivision. This is not necessarily an evil, but it emphasises once more the need for increased production and fertilizers.

The question of fertilizers, their kinds and uses, is intimately bound up with other considerations as tillage and tilth, water supply and farm pests. Fertilizers have to be considered in their chemical, physical and biological effects on the soil and crop. Their effects are direct and indirect. We have to take into account the after-effects of their application, to indicate sound and unsound practice, and to remember the peculiarities of our soils and climate. Fertilizers are applied in order to increase the useful productivity of the soil. They do this, first of all, by supplying needed plant food, that is, by making good the chemical deficiencies of the soil. Secondly, they assist in the elaboration of the store of plant food already in the soil in a dormant form. Thirdly, they allow of the growth of a crop with a minimum of water. Further, the soil is not rendered unhealthy or exhausted by the skilful use of fertilizers. For its own sake the soil, as soil, is not worth a thought. As a source of future crops, its composition and condition, ought to have careful study.

The productive power of the soil depends on.

1. The presence in adequate amounts of all the necessary plant-foods.
2. The presence of water and air; and
3. The absence of poisonous substances.

Fertility is not to be attained by fertilizers alone; fertilizers may easily lead to infertility.

It is not possible to consider all conceivable cases in an hour's time, but a few may be discussed.

Three things have been shown to be usually needed in fertilizers; four are sometimes included in this category. They are nitrogen, phosphoric acid, potash and lime. The order of importance varies in particular cases. Generally, the order in this country is phosphoric acid, nitrogen, potash, and lime. If kraal manure is conserved and utilised as it should be, the need for nitrogen and potash is very greatly reduced. Lime would then take second place. Fertilizers are classified according to the particular plantfoods they contain, as general, nitrogenous, phosphatic and potassic. A classification which ought to be noted is that which divides them into nitrogenous and non-nitrogenous. This division is important because of the effect of nitrogen on the growth and development of the plant. Nitrogenous substances favour the production of the vegetative parts of the plant, and give rise to the plentiful growth of stem and leaf. This tendency is sometimes inimical to the formation of the reproductive members, flowers and fruits. Where these are the object of cropping, the application of nitrogenous fertilizers requires discretion.

For the production of a full crop, the necessity of water must not be forgotten. Humus, though less essential, is still important, and demands notice. It will be convenient to illustrate general principles by means of particular instances. Before considering the different substances available as fertilizers it will, perhaps, be well to emphasize a few general cautions. The first is that care is required in the use of water soluble substances in fertilizers. Such substances, whatever their nature, are apt to be dangerous, inasmuch as they compete with the plant for water. When this is plentiful, no harm is done. It is the short droughts which occur more or less in every growing season, that are to be feared. When everything becomes dust-dry, the less water-soluble substance present the better. The proportion of such substance to the water available becomes very high, and extensive plasmolysis occurs with corresponding loss of crop. If water-soluble substances are absent, the plant has a much improved chance of surviving the dry time. Not infrequently injudicious fertilizing leads to a diminished crop. This caution is specially necessary in this land of bright sunshine. Another thing to be guarded against is that care should be taken to prevent the accumulation of sodium salts and chlorides in the soil. These are specially objectionable among water soluble substances, and, if present in fertilizers to more than a very small extent, such fertilizer should only be applied to vigorous growing crops, in the removal of which they may be largely taken away. Generally there is no great amount of percolating water. The rain that comes passes into the cultivated land, but there is not sufficient to pass through and carry away objectionable substances. Provision for drainage has not been made except in a negligible number of cases. The consequence is that objectionable substances, if applied time after time, may easily accumulate to a dangerous extent, and bring about infertility. Plants in the course of their growth exercise selective absorption. Water soluble substances of all kinds freely enter. Such as are required by the plant are fixed and built into its substance. Others pass out again. Of this class, sodium salts and chlorides are of common occurrence. They are not removed by percolating rainfall, or to any large extent in the crop, and if applied with regularity in fertilizers, they may, in the course of a few seasons, accumulate to a deleterious degree. Land subject to such accumulation becomes more and more infertile. All sodium salts are objectionable on this ground, even the nitrate. In this case, the acid radical is utilized by the plant, the basic radical is rejected. All chlorides are objectionable even potassium chloride. Here the potash is assimilated, the hydrochloric acid rejected. Water soluble potash salts applied with freedom may be dangerous, but such danger diminishes as the potash is absorbed by the crop. If the chloride has been used the objection to the acid radical remains, if the sulphate was employed, the acid radical is rendered harmless by formation of sparingly soluble gypsum with the lime of the soil.

For the foregoing reasons it is advisable to use mixed salts, such as kainite, carnallite, and the ashes of kraal manure or karroo bush with some care.

Taking available sources of nitrogen first, then it may be laid down as a general principle that in mixed farming properly carried out there ought to be very little need for the purchase of nitrogen. As much dung as possible ought to be made. Mealie stalks, so often wasted by wind and fire, should be shredded and made into manure by the oxen and farm animals generally. The reiterated objection to this procedure is the expense and impracticability of dealing with huge areas in this way. The advantages gained would soon more than meet the expense. The impossibility of dealing properly with big areas is surely a very good argument for dividing up. The decaying vegetable matter added to the soil by the free use of kraal manure, say, 8 to 10 tons per acre, is very beneficial and helpful to the growth of pretty well the whole range of crops. It is hardly possible to apply it to the wrong soil. It improves all. It supplies actual nitrogen in a great variety of forms, differing in availability. It provides a source of energy for the beneficent activities of a whole class of microorganisms which fix the free nitrogen of the air, and so brings that tremendous reservoir under toll for the crop. It produces a mellowness in the soil, and a capacity for absorbing and retaining moisture which is wholly beneficial, and quite different from the moist condition resulting from the use of hygroscopic salts. It enables the easy production of a tilth, and a favourable seed-bed. Its maximum benefits are shown on the most intractable soils, whether clay or sand. At this time its value ought to be recognised, and its benefits made known. In this land of cheap coal, and what might soon be immense areas of quickly grown fuel, it is very wasteful to use it as fuel, especially as the soils of this country are so generally deficient in humus. The conservation and increase of humus is very important; its beneficial effects are so varied and so marked and it so readily undergoes depletion in this warm climate. In grain-growing districts, where the livestock kept is insufficient to make dung, the advantages of humus in the soil may be secured by the growth of catch crops of various kinds, which may be ploughed in. The use of leguminous plants is commonly advocated on account of the fact that their growth leads to the fixation of atmospheric nitrogen. Disadvantges connected with legumes are that seed is often expensive and they are comparatively slow growing Farmers would be well-advised many times to make use of a quicker growing plant of some non-leguminous order. Such a plant may sometimes be grown when the other could not. It should be remembered that all plants in their decay make possible the fixation of free nitrogen. With sources of nitrogen like these properly made use of there should not be great need for other purchased nitrogen. It may be desirable in certain cases, where kraal manure is unobtainable, or the growth of a green manure not possible, to make use of organic nitrogen of animal or vegetable origin, or even, in the case of gross feeding crops, to supplement these sources by using ammonium salts or nitrates.

Nitrogenous fertilizers of the organic kinds are of animal and vegetable origin. We have the refuse of abattoirs, meat and blood and entrail, dried and ground. Bones usually contain 3% to 4% nitrogen in their finished form as fertilizer. The carcases of diseased and decrepit animals ought to be utilized. It ought not to pass the wit of man to deal even with a case of anthrax. Of the same nature and general character are the fertilizers derived from the refuse of fisheries. Two of the more prominent classes of this kind are instanced by the whale meat and bone, and cray fish offal. Animal matter of whatever kind ought uniformly to be made use of as fertilizer The refuse of tanneries and glue refineries and all the other industries based upon the elaboration of animal products should contribute their quota to the supply of the combined nitrogen. Generally, animal substances are associated with more or less fat. This is always highly valuable as a means of making soap and candles and lubricants, and should always be separated as completely as practicable, more particularly as fat is highly objectionable in fertilizers. Fat hinders the decay, and consequently interferes with the availability of the nitrogenous substance. As a result of its own decomposition, insoluble calcium salts of the fatty acids are formed, which largely prevent the free circulation of air and water in the soil, and correspondingly lower the fertility. Oil of vegetable origin is just as valuable on the one hand and objectionable on the other. The residue of oil seeds after the removal of oil is sometimes only useful as fertilizer, not being suited for animal food owing to poisonous or unpalatable properties. To be of service as a source of nitrogen, the refuse of oil seeds should be practically free of oil.

The dung of sea birds, guano, when fresh, is a valuable source of nitrogen, and is highly appreciated, and as widely used as its limited quantity will allow. These organic forms of nitrogen are of high value. Owing to their cost they are not likely to be too plentifully used They may be harmful when rich, readily decomposable material is used, say, with fruit trees or vines, or when a nitrogenous fertilizer is applied on a moist vlei soil to a seed crop. Nitrogen in ammonium salts and nitrates is usually more expensive than organic nitrogen. This is just an appreciation of its higher availability. The ammonium salt usually met with is the sulphate. The chloride is objectionable for reasons already discussed Ammonia is assimilated by plants directly to a slight extent. For the most part it undergoes the process of oxidation, known as nitrification. This results in the formation of calcium nitrate a nutrient salt of high value. The use of ammonium sulphate soon renders a soil sour, and to that extent, unfertile. This sourness can be corrected by an application of lime. Much nitrogen is lost by the wasteful use of coal in household fires and for industrial purposes Sodium nitrate or Chili saltpetre is largely imported into this country as a source of nitric acid used in the manufacture of explosives. A small proportion is used as fertilizer. It is, of all forms of combined nitrogen, the most readily used by plants, and the most quickly available. The effects of an application may sometimes be seen in a few hours. It is a favourite form for use as top dressing when a highly soluble plant food is required.

Nitrates are all easily soluble. They never accumulate in the soil. They are destroyed in the combined presence of moisture and organic matter. The repeated use of sodium nitrate has a bad effect on the physical condition of the soil, being destructive of tilth. The formation of complexes of soil particles, upon which tilth depends, is destroyed by the soda, which results from repeated applications of sodium salts. The soil attains the same condition as kneading it would bring about, a very bad condition for the germination of seeds or the development of plants.

With electric power sufficiently cheap it becomes possible to manufacture calcium nitrate.

Of more importance in this country, even than the question of nitrogen, is that of phosphoric acid. The soils of South Africa are generally more deficient in phosphoric acid than in any other plant food. Phosphoric acid is sent off the farm in nearly the whole range of produce, whether mealies or wool, dairy produce, or live stock, potatoes or lucerne. The deficiency cannot be made good by conserving kraal manure. It cannot be restored to the land by the practice of green manuring, for the green crop can return nothing in the way of phosphoric oxide it did not take from the soil. The air is no reservoir of phosphoric acid as it is of nitrogen. The soil, originally poor becomes only poorer by the practice of agriculture and the sale of produce. If production is to be increased and maintained it becomes imperative then to use phosphatic fertilizers in nearly every case.

Phosphorus is a highly active polyvalent element, which may be obtained in several states of oxidation, corresponding to each of which there are one or more acids. We have only to do with the highest range, the phosphoric acids. There are three of these. Two of them may be ruled out as of no agricultural interest. The one that remains, ortho-phosphoric acid, is quite sufficiently complicated, forming as it does, three series of salts with one base, neutral salts, acid salts, and mixed salts, in which several bases and acids occur. The principal and most useful source of phosphoric acid for agriculture is to be found in bones. These are now very difficult to obtain in sufficient quantities. The collected bones are steamed under pressure, or boiled to sterilize them and extract the fat. They are then allowed to dry and ground up and sieved, and then sold as bone meal, or treated with sulphuric acid, to partly dissolve them.

Basic slag has only been obtainable at prohibitive rates for a long time. It is a dense substance, and must be very finely ground. It is not suitable as a material for the manufacture of superphosphate on account of its low content of phosphoric oxide and high proportion of iron compounds, and the basic nature of the whole. The phosphoric acid is mostly present in a highly complex, easily decomposed molecule, described as a silico-phosphate of lime and ferrous iron. The phosphoric acid is for the most part easily available to plants, and there is therefore no need to dissolve it. Mineral super-phosphates are not made in this country to any extent, if at all. The mineral phosphate deposits of the country are too uniformly poor in quality to be worth manufacturing into superphosphate, or they are not adapted for the purpose by reason of their high content of alumina and iron oxide. The strongly acid high grade "super" and "double super," are not well adapted for unskilled use in this country. They should be applied to soils in calcareous districts, or in conjunction with agricultural lime. Otherwise the soil speedily becomes sour and unproductive. Superphosphate does, in many cases, produce a wonderful effect on the growth of the crop, for a season or two. Then it is found to become more and more ineffective owing either to increasing acidity or sometimes, where care is not taken, to the depletion of other essential plant foods, or an infertile condition may arise from a growing deficiency in humus. Superphosphate then should always be used in conjunction with lime in some form, and the supplies of potash and nitrogen should be watched. Then, if the humus of the soil is maintained, there is no objection to the repeated use of superphosphate.

The advantages of phosphoric acid in the soil may be derived from other sources. Guanos are often highly phosphatic, and are of high value, being readily available, especially in the cases where the phosphate is accompanied by organic matter. Then there are the residues known as bat guanos. These occur chiefly in caves in limestone districts, and vary very much in colour, composition, density and value. Of actual bat guano or dung, the proportion is very small. When this material is obtainable in a reasonably pure condition it contains 6% to 6·5% nitrogen, and from 11% to 12% P_2O_5. What is advertised and sold as bat guano, is often highly charged with red earth or calcareous or siliceous debris and sometimes contains very small proportions of nitrogen and phosphoric oxide. The proportion of nitrogen to phosphoric oxide is often low. It depends on the condition under which the material has accumulated, the extent to which decay has proceeded, and the source of origin of the nitrogen and phosphoric oxide. For, many a time, the conclusion cannot be resisted, that often the remains of larger animals than bats are being examined. Creatures have found their way into the caves and perished there, and their remains give value to the accumulations of ages. A bat guano containing from 6% to 8% P_2O_5 must be accounted a good sample. The nitrogen is often negligible. The phosphoric oxide is only soluble to a slight extent in 2% citric acid. This test, however, appears to be no very reliable guide to its value as plant food, and phosphoric acid in bat guano is generally safer and better value than phosphoric acid in mineral phosphates.

Mineral phosphates are of wide distribution in South Africa. No very great mass is to be found in any one locality. The quality is usually low grade. Where the phosphoric acid is plentiful it is associated with alumina or iron oxide, and is therefore not adapted for the manufacture of superphosphate. Treatment with acid being ruled out, we can utilize the mineral phosphates of the country (1) as they are in a finely ground condition, (2) after calcination with limestone, (3) after fermentation with organic matter, as peat or kraal manure. This last method of treatment is one often used by good farmers with bones.

The availability and value of the different insoluble salts of phosphoric acid for different orders of plants is not at all well known. It is in this direction, chiefly, that research is required. The work is laborious, its results are not startling, and, though important, rarely receive the credit due. Phosphates of mineral origin are usually highly insoluble in citric acid and ammonium citrate. They are therefore accounted highly unavailable as plant food. This is not always the case. To be of value they must be finely ground, and so made to expose the maximum surface area to the attack of decomposing agencies. These are oxygen and carbon dioxide of the soil, air, water with the acids resulting from the decay of organic matter, and the solvent effects brought to bear by the plant roots. The soil agencies operate uniformly on all insoluble phosphates, in proportion to their concentration or mass. Their effect depends on the nature of the phosphate attacked. For example, calcium exists in one state of oxidation only; iron exists in several states of oxidation. Iron phosphates are therefore subject to disruption by oxidising and reducing effects brought to bear alternately by air and organic matter. Calcium phosphate is liable to attack and solution by carbon dioxide to an extent that iron and alumina phosphates are not. Each phosphate is more or less easily attacked by organic acids according to the properties of the salt formed. Different orders of plants possess different powers of attacking and utilizing phosphoric oxide in its various insoluble forms. Swede turnips and peas can obtain phosphoric acid from insoluble calcium phosphate, oats are quite unable to do so. Aluminium phosphate is an excellent nutrient for all three plants, so, also, is ferric phosphate. A Free State farmer not long ago made the interesting observation that the phosphate on his farm was good for rape and wheat, but had a bad effect on potatoes. It was found to be aluminium phosphate. The effect of aluminium phosphate and other aluminium compounds on potatoes is under investigation. Alumina is not found in plant ash as a usual constituent, and in certain cases its compounds may be toxic, in others merely indifferent. The results of extended research are needed in order that safe, sound advice may be given in the utilization of ground mineral phosphates. The cost of grinding mineral phosphate should be comparable with that of grinding limestone for agricultural use. Prepared in some such way, the farmer could afford to use heavy dressings, and he could thus build up the phosphate content of his soil very rapidly. But there is the probability of his making some crops impossible by following such a course, and it should therefore only be adopted after careful enquiry and experiment.

There is not nearly as great a demand for potash as for phosphoric acid. Soils generally are comparatively rich in potash, so is kraal manure. For all that, it is one of the important plant foods that is liable to become diminished in amount below the profitable minimum. We have therefore to consider sources of supply and the suitability of the product for fertilizing purposes. Since the supplies from Germany were cut off, agriculturists have had to look for other means of providing the necessity. These have been found (1) in ash of various kinds, ash of banana trees, ash of Karroo bush, ash of kraal manure, sometimes sheep, sometimes cattle dung. The process of burning may be justifiable in the case of Karroo bush and banana refuse, and other material of like kind, with which there is no option, but burning kraal manure of any kind is a mistaken policy. It is convenient for use for many purposes, and the nitrogen and humic matter lost by burning would more than pay for the extra transport charges. The quantity of ash varies, and it contains from small amounts up to nearly 20% of potash. It depends on the material burned, on the district of origin, and on the manner of burning. Ash from some districts is well known to be rich in potash, while that from other places is just as notoriously poor. If care is not taken to exclude sand and earth from the material before burning, not only is the proportion of the potash reduced by its presence in the ash, but the solubility of the product is greatly lowered, owing to the formation of glassy substances The ash, properly prepared, contains its potash and soda largely as carbonates. These salts cannot be looked upon as in all respects satisfactory plant foods. They have a burning poisonous effect, and must only be used sparingly if they are to be of benefit; a heavy dose is harmful in the case of many crops and conditions. An effective way to reduce the proportion of soluble alkali is to allow the ash to lie in wet contact with gypsum, both in a finely ground condition and well mixed. Sodium and potassium sulphates are formed. These salts may be leached out if desirable. To get rid of the sodium sulphate is a troublesome process. This salt is, however, more tolerable in a soil than sodium carbonate.

(2) There is the potash in some of the felspars which are to be found somewhere surely in the wide expanse of this sub-continent. This material, if finely ground and used plentifully, might be effective. Research is required in order to determine whether such applications would be uniformly safe.

(3) Potash felspars might be used as sources of silica in the manufacture of cement, the potash being secured as muriate or sulphate. This is done in Canada.

(4) An investigation might be made into the extent and character and potentiality of that huge deposit of potassium nitrate said to exist somewhere in South Africa.

(5) The conservation and use of kraal manure on farms reduces the need for purchased potash, besides securing other benefits, such as increase of humus with its water-holding and food-fixing properties.

Where fertilizing is carried on lime is always needed in all but some limestone districts. Lime is essential as a plant nutrient. For this purpose most soils contain an abundant supply for years, and if this were all it would rarely be required. But lime is the cheap, effective, and in every way useful basic substance which enables the farmer to at once correct the acidity in his soil. The acidity is the inevitable result of high farming, and whilst it is favourable to a good physical condition in the soil, it has a very bad effect on the biological condition, helping forward the growth of many fungi responsible for various crop diseases, and hindering the development of micro-organisms useful in the elaboration of plant food. The lime applied is used over and over again, and is for the most part always undergoing changes in the acid substances it neutralizes. There is, as it were, a dance past of acid radicals. They come and they go. The lime does not go on for ever, like the poet's brook, but it is more abiding than the acids which it neutralizes for the time being. The acids are produced plentifully by the oxidation of organic matter in manured soil. The organic acids pass along from stage to stage of oxidation until finally the state of carbon dioxide is reached. The lime becomes bi-carbonated; carbon dioxide is set free in soil water and in soil air. It escapes into atmospheric air. It carries on a war in the soil against calcium phosphate which it decomposes. With the aid of ammonia it can even decompose calcium sulphate. Acids are introduced into the soil by fertilizers. The lime, as it were, passes along the acids formed in the soil and added to the soil, to the point of exit by volatilisation or assimilation, or in some cases, percolation. In this latter event the lime itself is lost. Lime is the only substance which can perform this function for soils. Of the commonly occurring salts of calcium, only the chloride is highly soluble. The general insolubility in water of calcium compounds is a great advantage. Magnesium is a powerful base but does not form insoluble compounds to the same degree, and its compounds are, besides, harmful in some way. Alumina and ferric oxide have weak basic properties, and are not adapted to maintain a healthy neutral condition in the soil water. Potash and soda are strong bases, but form soluble salts and are for this reason highly dangerous.

Lime containing a proportion of silica, whether combined or not, is not objectionable from a farmer's point of view. What is bad, in an agricultural lime, is a high proportion of magnesium. This accumulates and brings about an infertile condition. There are deposits of calcium carbonate very soft or already powdered, fairly free from magnesium carbonate, occurring naturally in this country. They are ready to hand and ready to use. In this country the carbonate of lime is far preferable to lime in a caustic form, whether lime proper or water slaked. These latter have a very much too drastic effect on the organic matter of the soil, which it should be the farmer's chief care to conserve.

The part of nitrogen in plant nutrition has already been referred to. Phosphorus in the form of ortho-phosphates is utilized in the production of the highly organised proteins, into the composition of many of which it enters. Potash has been found to be essential to the production of starch, and is specially advantageous to heavy crops and starchy crops like potatoes.

Certain facts have been proved as a result of farming practice: the benefit of phosphatic applications to crops like turnips and rape, for instance. It would seem that the same consideration applies to the mealie crop.

Soils generally are deficient in phosphoric acid, and this is the principal constituent to be applied in most cases. For some crops, and in some places, nitrogen is required. In some low-lying vleis for seed crops, nitrogen is to be rigidly avoided and, in order to attain success, it may be necessary to apply some agent to repress [illegible] growth, as sodium sulphate.

Increased production could be secured by the practice of crop rotation many times. The same crop is grown on the same land year after year with very bad effects on the yield, owing to the exhaustion of plant food and the development of unhealthy conditions.

In conclusion, it may be said that moral and intellectual qualities in the agriculturist are more important for increased production than any material thing. Knowledge is more necessary than nitrogen and to use foresight is better than to apply phosphate.

The President: Mr. Baguley is to be congratulated on his excellent paper on a most interesting and important subject, and this Society is very fortunate in having this paper read before it at such an opportune time.

There is one point which is very noticeable with regard to the subject dealt with in this paper, and that is that there is an enormous field for research work, which should be tackled as soon as possible in these days of food shortage, and I will ask Dr. Caldecott to speak on this subject.

Dr. W. A. Caldecott (*Past-President*): I have very much pleasure in proposing a very hearty vote of thanks to Mr. Baguley for his very instructive and very timely paper.

Some of our more recent members may not be aware of the meaning of the central emblem in the Society's seal. This represents a mealie or maize cob, and was included in the design of the seal at Mr. J. R. Williams' suggestion, to show that our Society embraced agriculture within its scope. Hence the present paper is appropriate from every point of view, and it is to be hoped will call forth the discussion which its importance warrants, and be succeeded by others dealing with the scientific and technical aspect of the agricultural industry. The author has given us so excellent a review of the chief principles involved in his subject that I trust he will add to our indebtedness to him by giving still further details in his reply regarding the use of fertilizers under South African conditions, such as the specific fertilizers mainly needed for staple crops and typical soils in this country.

As the author has pointed out, the question of increasing our food production in view of the world-wide shortage is of the utmost importance. Up to date, this year we have imported wheat at the rate of about £1,000,000 per annum, but we have no assurance that owing to shipping shortage such importation can continue indefi nitely, so that we have every reason to render ourselves self-supporting. For similar reasons, the imporation of fertilizers has practically ceased, and it is to be hoped that the strenuous efforts now being made to utilize the large amount of potential fertilizer from abattoir and fishery offal throughout the Union, which at present is wasted, will before long result in concrete results. The local production of a good many thousand tons of fertilizer annually towards the supply needed to meet our present demands would materially assist in helping this country to feed itself instead of relying as in the past on the oversea world for so much of its food requirements.

The author has referred to the general poverty in phosphates of South African soil, which all exportation of maize and meat permanently accentuates. Just as the air in the past and present constitutes the great reservoir of nitrogen, so it seems that the ocean constitutes the phosphate reservoir, and it appears possible that the American practice of catching fish for oil and phosphatic-nitrogenous fertilizer may ultimately have to be adopted in this country. The importance of phosphatic fertilizers in promoting root growth and accelerating maturity appears very important in reference to crops such as maize in districts with erratic rainfall and liability to frost.

Where the materials are available, the following instructions from McConnell Agricultural Note-book (p. 134) for preparing home-made superphosphate may be of use:

"Proportion of materials employed to make superphosphate of lime at home:—

1 ton ground boiled bones.

850 lb. (50 gal.) of brown sulphuric acid.

50 gal. of water to moisten the bones, and

50 gal. of water to mix with acid.

Mix gradually in a leaden or wooden cistern, and sprinkle on the acid: mix with ashes, earth, or gypsum, after a day or two, to dry the mass."

The author's statement, that fat in fertilizers retards decomposition is, of course, supported by the general statements of many authorities, but in view of the readiness with which animal fat undergoes decomposition and the favourable condition of this occurring in the soil, it would be instructive if in his reply the author could furnish us with any available experimental evidence in spport of the usual view.

Those of our members who are interested in the important subject dealt with by the author may desire to learn of some recent works on the subject, in addition to such well-known publications as Hall's "Fertilizers and Manures," and the periodical publications of the chemists of the Agricultural Department. Russell's "Manuring for Higher Crop Production (1916)," and "Soil Conditions and Plant Growth (1917)" contain up to date information for English conditions: the third edition of McDonald's "Hints to South African Farmers (1913)" contains useful information for Rhodesia and the Union of South Africa; and the Report of the Select Committee of the Union Parliament on Food Supplies, etc. (June, 1917), shews that a more general knowledge by farmers of the value and use of fertilizers would be of great value.

Mr. H. A. White (*Vice-President*): I have very much pleasure in supporting this vote of thanks to Mr. Bagley for his able and interesting paper. It is, I suppose, a well-known fact that the Witwatersrand is the principal financial fertilizer for all the industries of South Africa and, therefore, it is perhaps in order in this Society that we should have an opportunity of welcoming discussion on the agricultural fertilizers, more especially also as the Witwatersrand is by no means unknown to farmers for the interest it takes through its Agricultural Shows, and the support it gives to them. It is well and favourably known to farmers as endeavouring to support, not only the mining industry of the country, but also agriculture which is more permanent.

This subject is one we have not previously considered in this Society, but its importance, especially at the present time, cannot be overrated. Judging from the evidence recently taken before a Parliamentary Committee, it appears that throughout the country gross ignorance prevails in two important directions. The correct use of fertilizers, though subject to few general rules, requires a special consideration, not only of the soil but of the crops to be grown, and evidence of incorrect application is frequently recorded, and contentment is manifested with yields which could be largely and profitably increased by application of suitable manure in correct amounts. A knowledge of the resources of the country in this direction appears to be only slowly coming into existence, and the present Government may be congratulated on the steps it is taking in this direction. The matter is one of the utmost importance to the progress of South

Africa, and it is an excellent thing that the sub-committee dealing with this subject has Dr. Caldecott as its chairman, so that we may hope that its activities will be more largely expended in the direction of production of manures from waste products and from natural sources than in the accumulation of literature read by few and rarely studied by those immediately concerned.

The first steps are now conceded to lie in the direction of utilization of waste, such as that of municipal abattoirs and fishing companies, and the exploitation of natural phosphates such as those of Saldanha Bay, whose composition demands especial research before complete utilization can be made thereof. Such are the general problems before the country, and their urgent nature demands special and early attention, but in addition the whole subject is one upon which scientific research is urgently needed. Practice is in fact in all countries based far too much upon empirical results, and in every country the difference in the soils most frequently encountered and in the climatic conditions demands a thorough investigation from the scientific side as a base for extensive experimentation upon a practical farming scale. In this connection it may be observed that the practical farmer can only be irritated by reports from Government farms showing largely increased theoretical profits from application of various manures when he knows well that such farms are run at a huge loss. Government farms should be made to pay, and expert Government advice can only be really welcomed when it is based upon actually profitable results. If with unlimited capital and expert attention a Government farm is run at a considerable loss, it cannot induce the ordinary farmer to believe that science and farming form a profitable partnership. After all, the principal fertilizer is rainwater, and in this direction an intensive study of its conservation is of vital importance to the future prosperity of this country. Farmers who practise irrigation extensively certainly believe that direct rainfall is far more beneficial than an equal quantity of stored water, and this point is worthy of investigation. The difference may consist of a small quantity of ammonium nitrate and might be found to be remediable in a commercial manner.

Some success has recently been attained in America in the application of elementary sulphur as a manure, and it is possible that its success may lie in the direction of rendering available supplies of plant food already in the soil. In this direction the fact that sufficient content of potash, phosphorus, and nitrogen for 100 crops is not always looked upon as rendering unnecessary the addition of artificial manures containing these substances, and the effect of [illegible] additions suggests that a field is open for investigation of the possibilities of activation of present soil components.

The President: We have here to-night with us Mr Warington Smyth, the Secretary for Mines and Industries, and, as he has unfortunately not been to our meetings for some long time, I wish to welcome him here, and I would like to know whether he has anything to tell us on this important subject, from the Government's point of view.

Mr. H. Warington Smyth (*Secretary for Mines and Industries*): It is some time since I was among you, I regret to say, and I see a change has come over the scene; there are not quite so many present to-night as there used to be in the old days before the war.

I would like to say this: I think the paper we have heard to-night is extremely well-timed. I think it is betraying no secret to say that in the year before us we are likely to experience a much more serious shortage of shipping than has happened in the past; in fact, I am not looking forward to the year 1918 with very much pleasure. I have the misfortune to be dealing with the Priority Department, and I anticipate that there will be a great many more complaints against me next year than there have been in the past year, owing to the shortage of shipping and supplies that can reach this country.

What we are trying to do at the present time in connection with the Scientific and Technical Committee which has been appointed by the Government, is to investigate this very question of trying to produce fertilizers in our own country—to see to what extent it can be done.

Before going further, I should like to say this, that the reader of the paper and the subsequent speakers have all drawn attention to the fact that there is a great field for research.

It is only due, I think, to the Agricultural Department—of whom we have no representative unfortunately here to-night—to say that they have a considerable staff of experienced men—scientific men—who are doing their best to investigate some of these problems. They are very intricate problems, as has been indicated. You know more about that than I do. But the Agricultural Department is pursuing certain lines of investigation.

Now, the Scientific Committee, to which the Minister, in his opening speech last year specially referred the consideration of this question, has also appointed a Sub-Committee of its members, and is doing its utmost also to try and assist the Agricultural Department and assist the Government in opening up new lines from which we may obtain fertilizers.

The prospective shortage of shipping is, of course, a very serious matter from the point of view of superphosphates, and I may say that the Government is keeping its eye on this question in the hope possibly of being able to get some neutral tonnage and obtain possibly some superphosphates from Japan. But that source is very uncertain, and cannot be relied upon at the present moment. The Japanese Government has forbidden the export of superphosphates. On the other hand, they want very badly certain materials we may be able to supply, and the question arises as to whether we shall not be able to effect an exchange. Japan wants scrap iron. We cannot spare very much from this country at the present time. It is possible we may be able to spare a certain amount. Then it will become a question as to what price we can land this fertilizer. There is such a thing as landing it at a price out of reach of everybody, and, therefore, that consideration will have to be kept in mind.

As you know, to-day we are doing a great deal more than we were doing three years ago. The Ammonium Company of Natal is turning out sulphate of ammonia to-day, which is going to Mauritius, and, apparently, Mauritius is able to absorb all the Company's output for some years to come. At the present time it is producing 200 tons a month, and that will increase shortly. As soon as they can duplicate their plant a large increase may be expected. The export of any kind of fertilizer at present is prohibited, but the Company is allowed to export to Mauritius on condition that it supplies local demands first. Apparently—and, on this subject, I speak under correction, because you probably all know more about it than I do—sulphate of ammonia is not suitable to new soils. In Mauritius, where the sugar industry is one of many years' standing, that particular form of fertilizer is very much required and, as I say, Mauritius is taking all that the Company can turn out. But in this country at present our sugar industry has not attained the number of years of age which is necessary to require that particular class of fertilizer, and the amount being taken here at the present moment is thus very small.

The Scientific Committee is also investigating the other directions where there is, at the present moment, a wastage going on.

The wastage at the abattoirs has been referred to, and also the crayfish industry is a possible source of, I think, something like 12,000 tons per annum. The abattoirs themselves will provide a considerable source also. There is the question as to how people are to be persuaded because it will amount to that; I am afraid we cannot compel people—not to waste by-products; but some form of persuasion must be exercised: and I trust that we shall find our way in time. We have got to feel our way in the matter, and the whole subject is full of difficulty: but what we are trying to do at the present moment is to get something agreed and something done. It may take a bit of time, but, as I say, the prospects for the next year are so serious in regard to shipping facilities that we must absolutely do all that we can. The amount of wheat which we may be able to get from abroad next year will probably be measured in extremely small figures.

With regard again to the Saldanha Bay phosphates, the difficulty in regard to which is, as you all know, their insolubility, experiments are being made by Dr. Marloth and other persons. Prof. van der Riet of the Scientific Committee has also obtained some interesting results in experimenting on these rock phosphates. But even if results are satisfactory in the efforts being made to render them soluble, one essential condition of practical success will be cheapness of production in the finished article.

There are several things which I should have liked to have heard the reader of the paper give us in greater detail. I think his paper, as a general exposition to a person like myself, who is not a skilled chemist, is most valuable, and I think it will be read with a great deal of interest by many people in this country. But I should like him to explain to me why it is we cannot get our farmers to use whale meat more than they do. I believe there is a very large amount of it available at the present time; we are being asked to allow the export of quite a quantity. Locally, there seems to be considerable prejudice against its use. I understand one reason for this is because they claim that the fatty substance is against satisfactory decomposition. But I should like to hear, in the reply, if the reader of the paper could give us a little more information under that heading.

Water was mentioned just now—the conservation of water. The Scientific Committee, in regard to water supply generally, is working in conjunction with Mr. Kanthack, my colleague in the Irrigation Department, and I think there is a very complete understanding between the Committee and Mr Kanthack as to the importance of a water survey, and certain steps are being taken; a certain amount of money has been advanced to enable him to take a few more active steps than he has been able to do in the past for want of funds, and I think, therefore, that aspect is not entirely being lost sight of.

Sulphur was mentioned, and there again I am hoping we are going to begin shortly to produce our own sulphur. During past years, we know, it has been imported from Sicily. To-day it is very difficult to get sulphur, and I am very hopeful that we shall, before very long, be able to turn out our own. It may be rather unduly optimistic on my part, but I think the time will come, because, to-day, we are being thrown on our own resources, are being shown how to try and do for ourselves, and it is really extraordinary, when you come to look round, to see the amount of development that has taken place in the mineral line—the use of several base mineral and minerals of general utility—since the commencement of the war.

I thank you for asking me to speak to-night, and your members for allowing me to be present on this occasion.

The President: We are very much indebted to Mr Warington Smyth for coming here this evening and telling us what the Government is doing with regard to speeding up farming in this country, so that it may be self-supporting as quickly as possible. With regard to the research question, as Mr Warington Smyth has told us, there are many men of the Agricultural Department who are doing research work, but unfortunately such work takes time before the results of it can be turned to practical use, and unfortunately the time factor is at present a very important one.

Mr. F. W. Watson (*Member of Council*). With regard to phosphoric acid I would like to ask Mr Baguley a question. It is a chemical point and refers to the best method of determining the available phosphoric acid. One authority recommends agitating the soil occasionally with a 1% solution of citric acid for seven days; another recommends agitating continually for half-an-hour with a 2% citric acid solution. I would like to know if Mr. Baguley can tell us which is the better method.

Mr. A. Baguley: I think the use of 1% citric acid may be called "the ancient practice"; the use of 2% is the modern practice. As to what value is to be attached to the results—well, different people have different ideas. In my own opinion, the value I attach to the results is only small, as indicating the practical value.

Some years ago I was in a position to conduct a research into this question of availability of phosphates, and it indicated to me very clearly that artificial solvents of this kind cannot be regarded as generally applicable. As a result of these experiments I am not inclined to cast doubt or fear upon aluminium or iron phosphates, which occur freely in the mineral phosphates of this country. But there is a point now which makes me very doubtful about recommending the wide use of mineral phosphates, and that is the observation of the Free State farmer I mentioned. It was quite recent—it was a new thing to me—that aluminium phosphate is harmful to the potato crop.

The question regarding wattle meal and farmers' prejudice against using it, I should like a little more time to consider.

The President: I think we should get as much discussion as possible, because it will then bring out, or help to bring out, the details of the question, and so improve our knowledge.

Prof. G. H. Stanley (*Past President*). I take it that the present position is one of urgency, and what the Scientific and Technical Committee has in front of it at the moment is to try and find something which can be used even next year, if possible. That, of course, is very difficult indeed, and I hope they will be successful. But, in future, I am quite confident this country will be able to supply all the fertilisers it needs from within its own borders, although, under war conditions, it may not be [illegible]

ble to obtain all the necessary plant required for production.

With regard to nitrogen, the problem is really solved by the recent advances which have taken place in connection with the utilization of atmospheric nitrogen. That, however, will involve a very expensive plant, which we may not be able to get during the war, but after the war we should be independent; that is to say, if we can make the fertilizer cheaper here than we can import it. We have one present source of nitrogenous fertilizer in Natal, the supply from which might be very considerably augmented. We are told the ammonium sulphate people are producing it at a certain rate, but we are told also that they are simply blowing away the gas they are producing as a waste product. If that were to be utilized for generation of power it might produce an additional nitrogen supply from the atmosphere.

In connection with potash, there are said to be some large deposits of felspar in the country, some of them rich in potash, as much as 14 %. It may be, if they are sufficiently finely ground, that the potash may be directly available to plants. As Mr. Baguley has told us, plants can dissolve, by their root action, substances which are, to all intents and purposes, insoluble in ordinary solvents. Then, again, I believe there are quite considerable quantities of seaweed available on the coasts in different places, and I was interested to read,* only yesterday, that, in the United States, the Department of Agriculture is already erecting plant for the experimental production of potassium salts from the seaweed there. If it is correct that we have large deposits of seaweed on the coast, that may be followed up here also.

With regard to phosphates, the position is not quite so good, but we all look forward to seeing a very considerable iron industry in this country before very long and, in that connection, it is possible, or even probable, that we may be able to produce large amounts of the basic slag to which Mr. Baguley referred. It has become of such importance in Europe that when the amount produced by the normal operation of steel plants became insufficient, the Germans took the mineral phosphate and put it through their blast furnaces along with phosphoric ores. So that ultimately they increased the production of basic slag. I was interested the other day to note that we had a large deposit of limestone in the Northern Transvaal which contains about 3 % of phosphoric oxide. Normally, such a thing would frighten any ironmaster, but if, by the use of appropriate methods, the phosphorus reappeared in basic slag, it would represent an additional source of profit. Some of our iron ores are phosphoric, too, and by combining these materials, I am quite certain that in future we shall be able to produce all the phosphoric fertilizer we require, as well as potash and nitrogen.

---

* *Economic World*, Dec. 2, 1916.

A NEW METHOD OF DETERMINING COPPER.

By James Moir (Past-President).

The object of the author in inventing this process was to find a method of doing without the large quantities of the expensive potassium iodide required in the ordinary accurate process for copper. For example, if high accuracy is required in determining the true percentage of copper in a "pure" copper, about 4 gr. of the metal must be taken, involving the use of about 30 gm. of KI and 16 gm. of crystallised thiosulphate.

Now, if the equations concerned in the ordinary process be studied, it will be seen that the nett result of the addition of iodide and thiosulphate to cupric acetate is to produce an insoluble cuprous salt along with a soluble tetrathionate.

(1) $CuA_2 + 2KI = CuI + 2K\overline{A} + \frac{1}{2}I_2$

(2) $\frac{1}{2}I_2 + Na_2S_2O_3 = NaI + \frac{1}{2}Na_2S_4O_6.$

The nett result is as if the equation were

(3) $Cu\overline{A}_2 + KI + Na_2S_2O_3 =$
$CuI + K\overline{A} + NaA + \frac{1}{2}Na_2S_4O_6.$

It therefore struck me that the simple direct reaction between cupric salts and sodium thiosulphate would be worth reinvestigating. Now a number of double copper sodium thiosulphates were described by German authors 30 or 40 years ago, but it is probable that the whole of this work is wrong, and that the substances obtained were really tetrathionates and not thiosulphates.

When equimolecular solutions of copper

acetate (or copper sulphate in presence of acetic acid and sodium acetate) and sodium thiosulphate are mixed, the mixture is greenish yellow and, in my opinion, consists mainly of soluble cuprous tetrathionate, but also contains a proportion of unchanged cupric thiosulphate.

$$(4)\ Cu\bar{A}_2 + Na_2S_2O_3 = \ddot{Cu}S_2O_3'' + 2\dot{Na}\bar{A}$$

$$(5)\ 2\ddot{Cu}S_2O_3'' \rightleftharpoons \dot{Cu}_2S_4O_6''$$

Balanced reaction between cupric thiosulphate and cuprous tetrathionate.

Equation (5) is perhaps more intelligible with separate ions.

$$(6)\ \ddot{Cu} + \ddot{Cu} + S_2O_3'' + S_2O_3'' = \dot{Cu} + \dot{Cu} + S_4O_6''.$$

The action being a balanced one is not suitable *per se* for an analytical process; nevertheless it was obvious that the success of the old iodide method depended on the almost complete insolubility of the cuprous salt produced, else the above balanced reaction would occur. This was confirmed on trying to replace iodide with bromide or chloride (the cuprous salts of which are fairly insoluble), when it was found that the reaction was incomplete. However, on trying sulphocyanide (thiocyanate) as a substitute for iodide success was obtained. The above balanced reaction then goes entirely in the direction of cuprous tetrathionate because the cuprous ion is removed as insoluble CuSCN as fast as it is formed, and on filtration a *colourless* solution containing only $Na_2S_4O_6$ and excess KSCN and $Na_2S_2O_3$ is obtained, in which under special conditions the latter can be estimated with iodine even in the presence of sulphocyanide.

The analytical process suggested is therefore as follows:—Dissolve the weighed specimen in HNO_3, and get it into the condition of very faintly acid cupric acetate, either by the old methods or by the quick process which I describe farther on. Add a slight excess of thiosulphate in known quantity (1 gm. copper requires 3·904 gm. crystallised thiosulphate, or about 158 cc. of "N/10 thiosulphate") and (immediately) a sufficient excess of potassium sulphocyanide (equal to, say, 1¾ gm. per gram of copper). The white precipitate of CuSCN has then to be filtered off, roughly washed and rejected. Since it goes through every known variety of filter paper, and since the solution cannot be heated (else the trace of acetic acid would act on the excess thiosulphate) it is necessary to add a quantity of pulped filter-paper before attempting to filter: (this is made by boiling a loose-texture filterpaper in dilute caustic soda until disintegrated and neutralising with acetic acid); on filtering, about 5 cc. will come through turbid before the pulp chokes the pores of the paper, after which a clear filtrate is obtained. As there is very little excess thiosulphate in this filtrate, any *elaborate* washing of the CuSCN precipitate is a waste of time.

To finish the analysis, the filtrate is *first* diluted to about a litre and then treated with 5 to 10 cc. concentrated pure H_2SO_4 (do not use HCl which, in this country, owing to bright sunlight, always contains free chlorine) and a little starch solution and titrated back with N/10 iodine, only a small quantity being required if the directions about thiosulphate have been followed. The calculation is merely:

$$\frac{\text{cc true } N/10 \text{ thiosulphate at beginning} - \text{cc. } N/10 \text{ iodine}}{157{\cdot}3}$$

= copper present (in grams), assuming 63·6 for its atomic weight. The filtrate must *not* be titrated with iodine without the high dilution and the *mineral* acid, otherwise iodine is absorbed by the excess KSCN present. Iodine does not apparently attack dilute HSCN.

If the approximate percentage of copper in the specimen is *totally* unknown, the experiment must be done twice, (1) on a small specimen (0·1 gm.) using 16 cc. of "N/10 thiosulphate"; (2) repeating using thiosulphate equal to ("thiosulphate" minus iodine) of the first experiment. Thus if experiment (1) used 2·5 cc. iodine at the end, the correct "thiosulphate" for experiment (2) is at the rate of 135 cc. per gram of material. This means that the method gives high results for copper (102% to 105% of the truth) when a *large* excess of "thiosulphate" has been used, but is sharply accurate when the "thiosulphate" is just in excess.

If *great* accuracy is required, 2 or 3 gm. of specimen must be taken, in which case it is better to weigh out the thiosulphate required (see opposite). This is because 400 cc. of thiosulphate solution would have to be taken, and the factor of any thiosulphate solution is not generally known within 1 part in 500, besides being variable with temperature. The following is a description of some of my results with the method:—

(1) *Analysis of* $CuSO_4\,5H_2O$—0·2500 gm. in water treated with sodium acetate and

two drops HA, then with 12·19 cc. "$N/10$ thiosulphate" of factor 0·985=12·01 cc. true $N/10$ thiosulphate. At the end the diluted acid filtrate required 1·99 cc. $N/10$ iodine: the quantity of copper is

$$\frac{12{\cdot}01 - 1{\cdot}99}{157{\cdot}3} = 0{\cdot}0637 \text{ gm. (Theory } 0{\cdot}0636)$$

(2) "*Pure*" *Copper* (99·6% *by Iodide Method*).—0·1280 gm. dissolved: preliminary trial with 25 cc. thiosulphate used 4·4 iodine (and Cu=102%!) Second trial with 20·6 thiosulphate (corrected) used 0·54 iodine

$$Cu = \frac{20{\cdot}06 \times 100}{157{\cdot}3 \times 0{\cdot}128} = 99{\cdot}7\%.$$

Third trial with 20·5 thiosulphate used 0·40 iodine: Cu=99·85. These discrepancies are due solely to the smallness of sample taken, when one drop of reagent makes a difference of ¼% in the result for copper. If 1 gm. sample had been taken, an accuracy of 0·03% per drop could have been expected.

(3) *Electrolytic Copper* (*over* 99·9%).—0·1803 gm. dissolved: 29·3 cc. thiosulphate and 0·7 iodine used in first trial (Cu=100·7%): In second trial 28·60 thiosulphate (corrected) and 0·25 iodine: 28·35 difference or Cu=99·9%.

(4) *Copper-Nickel-Tin-Lead Alloy.*—After preliminary trial, 24·66 cc. (corrected) thiosulphate used for 0·2315 sample: iodine used 0·78∴Cu=65·6%. In this case the foreign metals were not separated and did not interfere, as Prof. Stanley's analysis of this sample by standard methods gave Cu=65·8%.

Owing to the nature of my process scarcely any of the common metals (except iron) interferes. Only such metals could interfere as are capable of being reduced from their *-ic* condition to their *-ous* condition by dilute thiosulphate, the *-ous* condition being then *not* oxidisable by iodine: so far as I can see, iron is the only metal which fulfils such conditions.

The quick process mentioned on p. 134 for getting the dissolved metal or ore into a condition for determining the copper depends on the little-appreciated fact that nitric acid is not an oxidising-agent if nitrous acid is removed from it. According to the ionic theory, dilute *pure* nitric acid consists only of the ions H′ and NO_3', the latter of which has no tendency to part with its oxygen unless a strong reducing-agent is added.

The metal or ore is dissolved in a covered vessel with *concentrated* HNO_3; the solution is agitated for a minute or two to get rid of as much dissolved NO_2 as possible, diluted to 20 cc. and treated with ½ gm. of urea (carbamide). After the effervescence has stopped the mixture is diluted to 50 cc. and boiled for 15 seconds. Thereon caustic soda is added to near neutrality, followed by 2 or 3 gm. of solid sodium acetate.

The analysis can then be proceeded with:

The destruction of the nitrous acid is explained by the equation:

$$CH_4ON \text{ (urea)} + 2HNO_2 = CO_2 + 2N_2 + 3H_2O.$$

Mr. John Watson (*Member of Council*): In proposing a vote of thanks to Dr. Moir for this valuable paper, I may say that, of recent years, I have not had much copper testing to do. Occasional samples I have tested, by the cyanide method of Parkes and C. Mohr. Years ago, on the Tyne, it was part of my weekly work, for several years, to test burnt pyrite for copper. There we used, first, the cyanide method, then the iodide method of E. O. Brown. Since the present great war broke out potassium iodide has gone up in price from 15s. 6d. per lb. in Johannesburg to 23s. (present price); so, other things being equal, this method of Dr. Moir's should be an economical one to those who have much copper testing to do. I am not prepared to discuss this novel method at the present time, but hope to experiment on it, if time allows, during the next few months. I have much pleasure in proposing a hearty vote of thanks to Dr. Moir for the interesting description of his ingenious method.

SILICOSIS IN RATS IN A WITWATERSRAND MINE.

By J. Pratt Johnson, M.B., B.S. (Lond.), D.P.H. (Oxon.).

(*Printed in Journal, March, 1917.*)

DISCUSSION.

Mr. E. M. Weston (*Member of Council*): These experiments on rats would perhaps have been of more value for purposes of comparison had the rats not been exposed to such severe conditions at blasting time. The short time taken for them to contract silicosis only makes one wonder that the ravages of the disease in the past among human beings were not more terrible than they were. The experiments can scarcely give us a guide as to the time under present conditions it would take to impair the lungs of underground men. We need to ask ourselves honestly what are the underground conditions to-day as regards the elimination of phthisis. Mr. T. P. Waites, a member of this Society, recently stated at a meeting of the Reef Underground Officials Society that "Again there is the great question of the day to us, the phthisis question. We are all satisfied that the present methods in vogue of laying dust are inadequate and that phthisis will not be a thing of the past by August, 1918." Mr. Waites had the courage openly and freely to thus express opinions which he evidently believes are shared by the bulk of his fellow officials, in the face of comforting official assurances. Is Mr. Waites right, and, if he is, what is to be done? I am very much afraid that men contact phthisis in the mines to-day. Conditions are indeed much better than they were in the evil days of ignorance and laxity; but they are bad in places to-day, and it is quite an open question whether a large proportion of underground employees are not breathing more dust particles than their lungs can stand. As manager of one of the shallowest, best ventilated, and generally most healthy sections on the Reef to-day, dust sampling has led me to the conclusion that in all development faces using piston drills, and in some cases where water-fed drills are used, dust in injurious quantities is produced several times during the shift, especially when collaring holes. The shortage of proper "Flottman" tubes due to war conditions has also greatly increased the amount of dust produced. I should like to read you figures from recent dust sampling and the remarks at the time by the Standing Committee of Dust Sampling. Let us take, for example, the following working places tested in a recent dust sampling:

2–1 Top Hammer Stope.—4 hammer boys working, 6 lashing boys, wetted down. 10·5 mgs. of dust.

[Note.—This stope was in oxidized ore, damp, and no boys were drilling dry holes, and the holes were well started.]

2 S. Drive.—1 3¼in. drill, hose and jet, wetted down. 9·0 mgs. dust.

1 S. Winze.—3 hammer boys, wetted down. 5·7 mgs. dust.

1 Drive S.—1 3¼in. piston drill, hose, wetted down, using tin can. 3·0 mgs. dust.

Two other stopes, where 10 and 11 boys are drilling, show 3 mgs. My attention was directed to the high average, and particularly to the horrible fact that a tin can was in use where the lowest average dust result was obtained!

In 3 S. H.W. drive, with one machine hose, *but using can*, 2·7 mgs. dust are present, and again my attention is specially directed to this serious contravention; whereas the serious fact lies in finding 7·2 mgs. of dust in a stope where one or two natives are drilling dry holes with swabs in use. Where two machines are in use in drives and collaring the dust found is from 7 mgs. to 8 mgs. Phthisis is not going to be eradicated by straining at such gnats as the use of a tin can occasionally in a flitter or knee hole, where it is really the most convenient and efficient method of keeping the hole full of water; but by asking how to prevent 5·7 mgs. of dust appearing down a winze at 11.20 a.m. when all natives were drilling wet holes, or 10·5 mgs. in a naturally wet oxidized stope, or how is the dust from dry hammer holes going to be prevented from pervading the stope?"

These results and others seem to show that sometimes dust in dangerous quantities appears without cause in well washed down and ventilated stopes, and that if even one or two natives are drilling dry holes, swabs are quite useless in stopping dust formation and diffusion. The dust then present reaches 5 mgs. to 7 mgs., making the atmosphere poisonous. The same things happens if hitches for timber are being cut, as they always are dry, or if rocks are being broken in the stope. Natives on grizzlies will not work under a spray, and dust is, I think, always present in large quantities at loading bins. It is quite open knowledge that the evidence of the Konimeter disturbs the pleasant illusion that 4 mgs. or 5 mgs. per c.m. in the air is a safe amount. I think, then, we must all admit that even if no smoke or dust remain from blasting operations, which is by no means always the case in the lowest levels, there are always certain foci of bad dust production in the mines from which certain workers are not at present guarded, and will not be guarded by the stress laid on matters of such minor importance as the use of a tin can in drilling certain down holes or in trying to make the native screw or unscrew his "Flottman" tube from his hose when starting holes and drilling them.

Now, regarding dust sampling, I am the

first to agree that it is of the greatest value if used by the underground officials to tell them where and how bad conditions arise, and I have learnt much by it; but I do say that there is danger of it degenerating into a farce, and that the system of making a sort of public competition of the results may lead to grave abuses. I have no reason myself to complain of results obtained in comparison with others; but if a manager or mine captain uses the dust sampler to find out what the conditions really are he may very easily get a bad name; whereas the man who manages things may get commended. I will not say anything more, or I may say too much on this matter; but I speak of what I know.

Cannot, then, phthisis be eliminated from the dangers to which our miners are exposed? The contraction of phthisis can be stopped, and stopped now. Some of us have always believed that some form of respirator was required to supplement the other measures of dust prevention. The trouble with respirators in the past were first that they did not arrest the fine dust, and, secondly, that few could wear them owing to the feeling of oppression, heat, and the resistance to breathing. For over a year now, with many delays, I have been evolving a type of respirator which I can now say is practical and effective. It was designed to copy nature's methods of safeguarding the lungs and to supplement and reinforce them. I do not wish at the moment to publish a drawing or exact description, but I would draw your attention to the fact that if nature has in her own way been able to provide a very efficient dust stopping apparatus in our breathing organs and yet leave a perfectly free passage through nose and bronchial tube, it should not seem an absurd claim that in my respirator there is a free opening of nearly ½ in. square right through, making making resistance to the passage of the air in breathing a minimum. I have to thank the Miners' Phthisis Prevention Committee for making some tests on earlier models. The first showing 90% dust stopped and the second 60% to 70%. I should like here, however, to point out that results should not be presented as percentage results. The only test of a respirator is: will it reduce the dust to about 3 mgs. or under, showing that it can arrest the very finest particles? Mr. Boyd kindly made some unofficial tests on improved models, with the following progressive results:—

Mgm. Dust in air.	Mgm. Dust passing respirator.	Extraction.
74	5·4	92·6
132·9	5·4	96
13·2	3·0	
9·6	3·3	

These results were encouraging, showing that the most poisonous air could be made much better. I then tried two experiments with the mine sampler, who, of course, had the testing in his own charge. Results with two different types:—

Mgm. in air.	Mgm. passing respirator.
26·1	1·1
27·2	1·1

Mr. Boyd then tested two types designed to give the maximum freedom in breathing:

Mgm. dust in air.	Type (1)	Type (20)
	Mgm. passing respirator.	
54·6	(fouled	3·0
55·8	0·9	2·1
6·0	trace	trace

Here I believe final success was achieved, as it was shown that the very finest dust could be arrested and a respirator of cheap and simple design was available.

I do not know if the Industry realizes that the results mean that it is now, I believe, possible to make the contraction of phthisis an unlawful act if necessary by making the use of a respirator compulsory on all engaged in certain work or in certain localities. Even if the use of a respirator that could be worn without discomfort and without hindering work merely increased the time in which a miner contracted phthisis 50%, surely it should be welcomed on financial as well as on humane grounds. It should also prove a great boon to workers in dry crushing reduction works, cement works, and various dangerous industries.

Mr. H. A. White *(Vice-President)*: What is the size of the respirator, Mr. Weston?

Mr. E. M. Weston *(Member of Council)*: It will go into your coat breast pocket.

The President: This subject has always interested me very much, and I have worn a respirator while underground, for the past 10 years, in these mines. I have used a flannel type of respirator with several layers of flannel. I tested this type of respirator in conjunction with Mr. Rusden, and the results of our experiment appear in this Society's *Journal* for November, 1915, and I would refer those interested to the results we obtained. Since Mr. Weston told me of his respirator I have tested one, of a somewhat different pattern, working on the same principle, in conjunction with Mr. Toombs, and the results so far obtained are quite promising. I think that, as the result of a little more research work an efficient respirator will be designed.

THE CONSTRUCTION AND MAINTENANCE OF SLIME DAMS.

JAS. E. THOMAS (Past-President) and
E. A. OSTERLOH (Member).

(Printed in Journal, June, 1917.)

DISCUSSION.

Mr. John D. O'Hara *(Member):* I have followed this discussion with interest, the subject being such an important part of the reduction works. Mr. White's view is one I have always advocated, *i.e.*, one of the first things that should be considered in opening up a new mine being the site for the slime dam and sand dump. The estimated tonnage, reckoned on a basis of slime, nowadays up to 60 of tons milled, equals the size of dam to be made, and allows for extra tonnage. It should be built of waste rock, ashes, and soil from all excavations done from time to time. The metallurgist who "joins up," so to say, after the mine is ready for milling, formerly, and as far as I am aware it is the same to-day, is in for a worrying time building a dam. The waste rock has been already dumped anywhere, and if he decides to use it, it means twice handling, an expense which could have been avoided, whereas if the dam had been gradually built from the start, it would have meant more time available to devote to other difficulties which are always found in starting up a new plant. When deciding on a new site, it is advisable to go a little further than has been done in the past, instead of just outside the extractor house door. Since slime was first treated many years ago by Mr. J. R. Williams, it has been always in my mind, having shared the trouble, what a "bug-bear" slime dams are to the man in charge. On taking over here (Nigel Company) in 1904, I was faced with the problem of making a new slime dam. After deciding upon the site, I obtained permission from the management to use waste rocks from the dumps and from the mine direct. I obtained all the old rails that I could lay my hands on, also a number of old trucks. First, after throwing up about two feet of earth all round, I used end tipping trucks, and built a vertical wall about three feet high, all round, excepting one portion where the old sand dump joined. I then tipped sand inside the wall. The dam was then ready. The slime was then worked both ways round the dam, which allowed the slime to dry, which was then thrown up on the side of the wall. I found that sand and slime mixed well with the waste rock, as being intermixed it prevented leakage, as the dam gradually filled, I raised the rails, filled it in with waste rock and sand, at the same time building up the slime as well. Only waste rock was tipped on the outside of the dam wall, or I should explain waste rock was tipped both sides, but sand only on the inside. The angle of the wall was the same, only a bit steeper than when built in steps or terraces. The waste rock, one may say, forms a fairly solid wall, forming its own angle of rest. Heavy storms have no effect on it, possibly being built of stone the heavy rains drain off better. There is always plenty of waste rock on a mine, so that one can easily strengthen both sides of the dam. Ashes could also be dumped inside as well, which would tend to do away with the unsightly ash dump. A dam built of waste rock is not the eye-sore one meets along the reef, there being no breaking away after a heavy storm, with its concurrent crowd of boys filling in cracks and washaways.

I agree with Mr. Fraser Alexander that piping is better than wood launders in draining off solution, and in all dams extra large piping or launders should be placed, solely to cope with storm water during the wet season. The Nigel has its full share of storm water. Where possible, an open trench, not a narrow one, which would block too easily, but one say about 2 ft. deep and 5 ft. wide, cut right round the dam, inside the fence, in case of any solution breaking through, especially when the lay of the ground and the surrounding country tends for storm water to wash at any part the base of dam.

A dam properly built from the start of mining operations with waste rock, ashes, etc., as mentioned before, costs but little to maintain and infinitely less trouble in the future. In these days of big tonnages and more slime, it is safe to assume that ample provision should be made at an early stage of a mine's life.

MULE HAULAGE UNDERGROUND AT THE DURBAN ROODEPOORT MINE.

By A. P. Rouillard (Member).

(*Printed in Journal, August, 1917.*)

Mr. E. M. Weston (*Member of Council*): The following notes on mule haulage in American mines may be of interest, they are taken from the *Engineering and Mining Journal* of New York. A mule hauls at the rate of 100 tons, 1,500 ft. in 8 hours, at a cost of 5 to 6 cents. (2½d. to 3d.) per ton. Cost of mule haulage compared with electric haulage:—

Mule Haulage:

Distance hauled	700 feet.
Tons hauled	81,145
Costs per ton:	
Driver	0·0230 Dol.
Maintenance of Mules ...	0·0051 ,,
Car coupler	0·0119 ,,
Car greaser	0·0059 ,,
Total	0·0458 ,,

or 2½d. per ton.

Electric Haulage:

Distance hauled	1,750 feet.
Tons hauled	136,272
Costs per ton:	
Engineer	0·0138 Dol.
Brakeman	0·0122 ,,
Oil	0·0018 ,,
Gasoline	0·0107 ,,
Repairs	0·0151 ,,
Car coupler	0·0164 ,,
Total	0·0700 ,,

or 3½d. per ton.

Mule haulage is considered best and cheapest for hauls of about 700 feet.

ELECTRIC FURNACE MANUFACTURE OF SHOES AND DIES ON THE WITWATERSRAND.

By Geo. H. Stanley, A.R.S.M., F.I.C., M.I.M.M. (Past-President).

(*Printed in Journal, September, 1917.*)

DISCUSSION.

Mr. J. A. Woodburn (*Associate*): From Prof. Stanley's description of this experimental electric furnace, and from the operations so far conducted, one gets the impression that the furnace is more of a melting furnace than a smelting furnace, that is to say, the metallurgical range is very limited. The early troubles were evidently caused by oxidation and loss of carbon and manganese, and from the analysis of the shoes and dies produced evidently a little silicon as well. By adding charcoal to the top of the metal and exercising care in closing tightly the top of the furnace, also by removing the rust and scale on the scrap before charging, the oxidation and slagging appears to have been evidently considerably reduced.

After giving analysis of the various imported shoes and dies, the scrap of which is used in the furnace, Prof. Stanley says, "that manganese is available in the form of available scrap steel, silicon and carbon in selected cast-iron scrap and pig, carbon by gas retort carbon, and charcoal, and of aluminium there is sufficient to last for a considerable time." Then later he states, "At this stage the required amount of pig iron and manganese steel is added," but gives no indication of what quantity is added, nor how the quantity is arrived at. As this is the crucial point from a metallurgical point of view, a little further information would be most interesting.

The charcoal covering on top of the charge evidently tends to replace any carbon which may be oxidized, and even adds more than enough, yet in the analysis given of some of the shoes and dies produced, while the carbon is evidently high, the silicon is on the low side and the manganese is very variable. From the care taken to clean the scrap and to melt it with as little oxidation as possible, and from the fact that no information is given regarding the quantity and contents of the slag, one gets the impression that it is difficult to regulate the contents of the charge before tapping, and the operation is therefore limited to melting down steel scrap of fairly uniform quality and producing castings of practically the same average quality. The adding of charcoal to the top of the charge is evidently an attempt to prevent a hurtful effect in the furnace rather than to produce a desired result, and no doubt this charcoal should be limited to the prevention of oxidation only. In the electric arc furnace the metal continually circulates from the bottom of the charge to the surface, and a thorough mixing of the various qualities of metal takes place, also thorough oxidation of all impurities can be obtained, and then the required addition of carbon and metals to produce the desired quality of steel can be added. This circulation enables a homogeneous mass to be poured, but in the induction furnace as described in the papers by Professors Stanley and Buchanan, the metal does not revolve around the channel, and it is difficult to see how a counteracting effect of losses in melting can be obtained, unless by adding the desired metals or minerals in a powdered form around the surface of the charge. In considering therefore the future production of steel from various qualities of scrap or from pig iron locally produced, one must rely on either the basic open heart furnace or the electric arc furnace, as the induction furnace as described is too limited in its range for dealing with other than definite qualities of steel. Slags, for instance, forming in any quantity would seriously interfere with the proper working of the furnace. The erection of the smelting furnace at Vereeniging, which I presume will be an arc furnace, should give an increased demand for graphite and pure carbon, and its successful working should lead to a greater demand for pig iron, even of secondary quality, of which there should be no difficulty in producing unlimited quantities.

The results as shown by Prof. Stanley's and Prof. Buchanan's papers clearly indicate what has to be faced in starting any new industry, and emphasises the necessity of beginning on a small scale and finding out all there is to be overcome before launching out on a larger scale, and the successful operation of this furnace for the purpose for which it was designed affords the assurance that initial difficulties can be overcome and successfully coped with so as to produce an economical result.

The President: As it is now time to close the meeting, I would ask those who have any contributions to the discussions on these papers, which are down on the Agenda for discussion, if they will please send them to the Secretary for inclusion in the *Journals* for December and January, as there will not be another meeting before February next.

The meeting then terminated.

Contributions and Correspondence

CONVERSION OF INSOLUBLE PHOSPHATES

The sample of Saldanha Bay phosphates experimented with was obtained from Prof. Van der Riet, of Stellenbosch.

This sample contained:—

Total phosphates	20·6	P_2O_5
Soluble phosphates	0·4	P_2O_5

A.—*Fusion with Calcium Carbonate.*—A mixture of 25 gm. of the sample, and 15 gm. calcium carbonate (Lucerne, Lime and Fertilizer Co.), the whole being finely pulverised, was placed in the furnace and kept at a temperature of about 1,100° C. for an hour and a half.

The caked mass was removed from the crucible, and weighed 29 gm.

Total phosphates ..	17·2	P_2O_5
Soluble phosphates ..	6·4	P_2O_5

B. — *Extract from "Fertilizers and Manures," by A. D. Hall, p. 135.*—"Wolter phosphate is made by melting together in a regenerative furnace 100 parts of powdered phosphorite, 70 parts of acid sodium sulphate, 20 parts of carbonate of lime, 22 parts of sand and 6 or 7 parts of coke, the molten material being run into water and then finely powdered. The resulting phosphate is almost wholly soluble in dilute citric acid, and has proved in experiments to be more assimilable by the plant than phosphoric acid in basic slag, and almost equivalent to phosphoric acid in superphosphate."

1.—A mixture of 100 gm. of the Saldanha Bay phosphate; 70 gm. of sodium bisulphate; 20 gm. of carbonate of lime, and 6 gm. of powdered coke was finely pulverised and charged into a crucible. This was heated in a crucible furnace for over an hour, the heat being applied gradually and finished at about 1,100° C. for half an hour. The mass was clinkered and would not pour. It was, therefore, cooled quickly, and detached from the crucible by breaking the latter. After lixiviating with water, the insoluble portion was found to contain 6·7 P_2O_5 (soluble in citric acid).

2.—A mixture of 25 gm. of Saldanha Bay phosphate; 17½ gm. of sodium bisulphate; 11 gm. of carbonate of lime; and 1½ gm. of powdered coke was finely pulverised and charged into a crucible. This was heated in a reverberatory furnace for about an hour at a temperature of 1,100° C. The sintered mass would not pour, but was easily detached from the crucible. Weight of friable mass, 36 gm.

This was pulverised and treated three times with about 200 cc. of water, each wash being decanted. Weight of dried insoluble portion, 31 gm.

Total phosphate in mass ... 13·8% P_2O_5

Soluble phosphate in mass ... 12·4% P_2O_5

The total phosphate in the sintered mass after washing in water therefore represents 91% of the total phosphate in the ore, and the soluble phosphate in the mass 81·8% of the total phosphate in the ore.

On a large scale, inter-action of the mixture would probably be effected by treating in a regenerative or a reverberatory pan furnace, or by briquetting it either with or without the addition of molasses and burning in an oven.

The soluble phosphate figures given above were obtained by treating 2 gm. in 200 cc. of a 2% citric acid solution, agitating continuously for half an hour.

A. McArthur Johnston.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Cellulose and Chemical Industry. – "The chemical industrial developments of cellulose are characteristic of the modern age, which in this section of technology dates from 1866. At this date the necessity of meeting the progressive consumption of paper by a supply of original raw cellulose material led to the introduction of esparto grass by Thos. Routledge, and to the investigation of wood material as the most massive form and source of cellulose. As the result of the pioneer work of an Anglo-Swedish group, of which the late C. D. Ekman was a prominent member, and for which his English collaborators (Messrs. Thomson, Bonar and Co., and George Fry, of Berwick-on-Tweed) supplied the means, the business organisation, and a considerable contribution to the technical and scientific basis of investigation, the wood pulp (cellulose) industry was launched.

It was considerably developed by the technical improvements introduced by our countryman, Edward Partington, now Lord Doverdale, who also brought to bear on the industry organising and business capabilities of a high order; the results, which have been cumulatively successful, are known to the world.

In these processes of resolving raw material into paper-maker's 'pulps,' the cellulose, as the chemically inert or non-reactive basis of the raw materials, resists the severe treatments required to attack the non-cellulose components. The esparto compound celluloses are resolved by alkaline treatment (caustic soda solution at 120°—130°), the wood substance (ligno-cellulose) by treatment with acid compounds (bisulhpites) in solution at 140°—160°.

The soluble by-products, derivatives of the non-cellulose complex, amounting in either case to 50% of the original raw material, are in effect waste products. In the case of the esparto they are burned incidentally to the recovery of the soda; but the 'wood liquor' by-product is still in the main a waste, and a colossal one.

The 'positive' chemical technology of cellulose is necessarily based upon its reactivity, and the industries which exploit the reaction changes of cellulose are of widely divergent character; those of Group A are based upon reactions of decomposition; those of Group B are based upon the properties of synthetical derivatives.

Of Group A, the resolution of cellulose into sugar (dextrose) by acid hydrolysis is the basis (1) of a process for the preparation of industrial (ethyl) alcohol from wood, and more economically from wood wastes. According to our latest information, the technical difficulties presented by this apparently simple process have been so far overcome that the alcohol is produced on the large scale at a cost of 2½d. per gallon, exclusive of the small cost of the waste wood material. Under these most favourable conditions, however, the yield of alcohol is only 5% of the weight of the wood substance, or say 8% of its cellulose content, leaving therefore a very large item of final waste to the debit account of the chemist.

(2) Sawdust, or other wood waste, fused *i.e.*, heated at high temperatures with the caustic alkalis is destructively oxidised, and the main product of the oxidation is oxalic acid; this process is in effect the main source of the acid, as an industrial product.

(3) Waste wood subjected to destructive distillation in closed retorts is resolved into gaseous and volatile liquid products, with a solid residue of charcoal or pseudo-carbon. The liquid products contain acetic acid, acetone, and methyl alcohol as chief constituents, and have been the main source of supply of these chemical individuals, which, as reagents especially, are indispensable in modern chemical industry.

In this direction, however, cellulose material and its wasteful treatment by destructive distillation are being supplanted by a direct and controlled synthesis from calcium carbide, acetylene being quantitatively transformed into acetaldehyde, and this into acetic acid. In this new industry the pioneers in this country are the British Cellulose and Chemical Manufacturing Company, Spondon, Derby.

(4) Cellulose treated in full contact with oxygen is burned with the familiar flame combustion: but from all the natural structural forms there is a residue of inorganic matter (ash) which when present in important proportion preserves the general structural details of the original. This intimate combination of cellulose with inorganic matter is a characteristic property of colloids of which cellulose is the prototype. It is the basis of innumerable processes incidental to the dyeing and colouring of cellulose fabrics and tissues. But the production of a combustion skeleton for utilisation as an industrial product is a modern and noteworthy realisation of a primary cellulose quality 'strong even in death.'

The familiar incandescent gas mantle is the skeleton of a textile material impregnated as such, or as we may say, 'in the flesh,' with colloidal thorium and cerium oxides, and afterwards cremated.

Of the cellulose industries of Group B, those (1) based on the nitric esters are of preponderating importance, for they include the production of the modern military explosives and they connote developments in pure and applied science peculiarly characteristic of the age. Cellulose nitrate not only fulfils the ideal of chemical effect, *i.e.*, total conversion of solid into gaseous matter, at maximum increase of volume (or pressure), further increased the temperature of combustion, but is a stable form of this high chemical potential, and further owing to its colloidal plastic properties can be moulded into any desired form and so the more able to meet the most exacting specification of ballistic requirements. There is no doubt that mankind is directly indebted for its 'smokeless' powder and the basis of the vast developments of modern military power to the pioneer work of Alfred Nobel and his collaborators.

The lower degrees of 'nitration' of cellulose are represented by products which are the basis of celluloid, and the celluloid industries connote the production of a large number of familiar objects both useful and ornamental, and a progressively increased production from the date of the pioneer work of the American inventor, Hyatt (1869).

Celluloid realises a very high order of plasticity, and it is this structural potentiality which enables it to maintain its industrial leadership in spite of its disadvantages of high inflammability frequently and tragically manifested.

(2) The analogues of the nitric esters are the acetic esters of cellulose derivatives, which are necessarily colloids with plastic capabilities, water resistant as are the nitrates, and with a higher order of resistance to heat (unchanged at 200° C.), and the ordinary inflammability of organic substances. Important uses of the cellulose acetates already established are: (a) in aeroplane construction, for treating to render taut and impermeable the textile fabric which constitutes the air resistant surface of the wings; (b) in the form of film, as the 'cinema film' support in photographic work, notably for the preparation of the continuous cinema picture; (c) for a varnish for metallic surfaces, and notably for electrical insulation and applications which depend upon exceptionally low inductive capacity.

In the above brief account of the cellulose nitrates and acetates there is the implicit suggestion of the production of artificial textile threads by drawing the solutions of these bodies through orifices of suitable form and dimensions such that after removal of the solvent liquid the re-solidified and structureless ester constitutes a cylinder of hyaline material of uniform diameter.

The industrial production of artificial threads, and notably of the 'silk' or lustra cellulose, we owe to the pioneer enterprise and purposeful tenacity of a French technologist, H. de Chardonnet. But cellulose nitrate as *matière première* has many and obvious defects; hence the alternative plastic forms or derivatives of cellulose have progressively displaced the original industrial product, which had a brilliant career of success in the early years of this century.

There are three main rival processes of which the underlying principles are common. They are expressed in the stages or phases of the process:—

(1) Cellulose is transformed by reaction into a synthetic derivative dissolved as such to an 8% solution (calculated as cellulose), filtered and continuously projected, or drawn through fine tubes or orifices into a solidifying or setting medium.

(2) The thread as a unit filament (monofil, crin, crinol), or multiple group of twisted filaments (artificial silk), is a cellulose ester or other derivative, and is chemically treated to remove combined groups or impurities as by-products of decomposing reactions; the thread substances is cellulose, reappearing as such after the cycle of changes.

The three cellulose derivatives on which these important industrial processes are based are: (1) The nitric esters; drawn or 'spun,' as ether-alcohol solution (Chardonnet process).

(2) The ammonia-soluble cellulose-hydrate copper hydroxide compounds (Cuprammonium process).

(3) The xanthic or sulphocarbonic ester, synthesised in two stages: (a) mercerisation of the cellulose; (b) combination of the alkali cellulose with carbon bisulphide, and solution of the product in water (Viscose process).

Of these the Viscose process is now predominant by reason of its advantages, technical and economic. It will be noted that the material 'elements' of the industry are cellulose, common salt, carbon and sulphur, than which no simpler terms could be devised, even as an *a priori* proposition.

Of other industrial applications of the Viscose process, the production of transparent film in continuous length is a variation only of the process above described, the liquid viscose being drawn through a controlled adjustable slit of 1·5 m. width, into a setting solution or precipitant, which converts it at once into the solid state, but retaining 50% of water. This hydrated product is purified by successive treatments, and is finally dehydrated and dried with a shrinkage of 33%, the 1·5 m. of hydrated xanthate, as first precipitated, being reduced to a width of 1 m. in the finished cellulose film.

This is a noteworthy achievement in chemical engineering, and is entirely due to the inventive presistence of the personnel of the Société Française de la Viscose, especially to MM. L. Naudin and J. E. Brandenberger. It is a pleasant duty to recognise technical pioneer work of so high an order.

In addition to these main applications there are many other uses of the reactions involved in the Viscose cycle. Thus 'mercerisation' of cellulose is an application of the interaction of cellulose (textiles) and caustic soda, to produce lustre effects and finishes upon cotton goods. The structural changes of yarns and cloths determined by these reactions were investigated by John Mercer at a period which long antedates our half-century of progress. To Mercer's anticipations there succeeded a long incubation period. A few discoveries of minor import in this field then revived interest in the major product: the alkali cellulose of the Viscose cycle and 'mercerised goods' became a textile market of first note and importance."—C. F. Cross, *Journal Soc. Chem. Ind.*, May 31, 1917, p. 531. (J. A. W.)

METALLURGY.

Sodium Sulphide Precipitation at Nipissing.—"The recent rise in price of Al dust and NaOH, involving additinnal costs of $33,000 per year if their use were continued has caused the adoption of the Na_2S method for precipitation of Ag at Nipissing. The sulphide is dissolved in an iron barrel divided by a vertical partition reaching almost to the bottom, into which flows a constant stream of barren solution from the filter press. The overflow from the opposite side carries the precipitant to a vat where it is agitated with pregnant solution, which is then pumped to the filter press. Desulphurisation is effected by the use of Al and NaOH (0·006 lb. and 0·03 lb. per oz. Ag, respectively) in a vat equipped with a stirring device for agitating the pulp. The resulting product after being washed and pressed is charged in a reverberatory furnace which puts out a bullion 996 fine. Au is not precipitated from cyanide solution by this method nor does Cu come down if sufficient cyanide is present."—R. B. Watson, *Eng. Mining J.*, *103*, 378-9, 1917.—*Chemical Abstracts*, May 18, 1917, pp. 1120-1. (J. G.)

Electrolytic Zinc.—"A pamphlet published by the United States Geological Survey, compiled by C. E. Siebenthal, relating to the output of zinc in the United States during 1916, contains a paragraph on the production of electrolytic zinc. Mr Siebenthal reports that the total capacity at the end of 1916 was not as great as the original estimate of the Survey, and, instead of 60,000 tons, the actual rate of output was 40,000 tons per year. This fact was due to the delay in completing several plants. It is stated that when the plants now under construction are at work the yearly capacity will be 85,000 tons. The actual output of electrolytic zinc during 1916 was 12,916 short tons, of which 1,800 tons was produced by refining prime western spelter, 887 tons was refined from scrap and dross, and 10,229 tons was produced direct from ores by leaching and electro-deposition. The total production of zinc in the United States during 1916 was 667,456 short tons. The accompanying table gives particulars of the electrolytic zinc plants in the United States. In writing of electrolytic zinc in North America, it is desirable to mention also that one of the most important plants is at Trail, British Columbia."—United States Geological Survey Pamphlet.—*Mining Magazine*, June, 1917, p. 317. (H. R. A.)

Cobalt and Its Uses.—"Almost the whole of the world's supplies of cobalt ore now come from the mines of Ontario, Canada. The metal cobalt, which has been called the twin sister of nickel, has not only grown in importance during the last few years, but its utilisation is confidently expected to become a much bigger thing in the near future, partly on account of the remarkable results obtained with it in electro-plating and also on account of the possibilities of an extended use of the alloy 'stellite.'

The consumption of cobalt is at present comparatively small, and it is thought that a reduction in price would lead to many new uses of the metal. The output from Canadian refineries could be readily increased if the demand warranted it. An expanding demand would be an important matter for Ontario, where the Provincial Government is quite alive to the fact and has already greatly assisted the development of the industry by granting a bounty on cobalt produced. The rate of this bounty is six cents per lb. of metallic cobalt, on all cobalt and cobalt-oxide refined in the province. The Dominion Government has also assisted the investigation of the metallurgy of cobalt and new applications for the metal by a vote for research work in the metallurgical laboratories of Queen's University, Kingston, Ontario.

Up to a few years ago, the chief, if not the only, uses of cobalt were for the production of a blue colour in glass and on porcelain, in the enamelling trade, and in the manufacture of paints such as cobalt blue. For these purposes a few hundred tons a year were sufficient to meet the world's requirements. Supplies were derived from the ores of New Caledonia which were shipped to Germany for extraction of the metal and the preparation of the salts and compounds. New Caledonia, however, cannot compete with Ontario, and her shipments of cobalt ores have practically ceased.

Cobalt is now being recovered at the smelters at Deloro, Thorold, and Welland, in Ontario, from the rich silver-cobalt-nickel ores of the cobalt district. The cobalt chromium alloy stellite is also being produced there.

Ferro-cobalt containing about 70% of cobalt is the form in which cobalt is added to steel to increase its hardness. Steel containing 4% of cobalt, in addition to chromium and tungsten, is one of the best high-speed tool-steels, from which machine tools are made that retain their edge even when raised to a red heat by the friction of working.

Stellite is a new, non ferrous cutting metal, originally an alloy of cobalt and chromium only, but tungsten and sometimes molybdenum are now added to increase its hardness. It contains no iron. The use of stellite in cutlery is of special interest. Knives of this alloy do not tarnish and are unaffected by fruit acids.

Small quantities of molybdenum are said to be added to the chromium and cobalt, which are the main constitutents of stellite with good results. To an alloy consisting of 85% cobalt and 15% chromium 25% of molybdenum was added and resulted in a fine-grained metal of excellent colour and lustre which ought to find a wide use for cutlery.

In electro-plating, cobalt has several advantages over nickel. For instance, a smaller quantity gives a more durable plating, and the plating operation can be conducted more rapidly. Another new use for cobalt salts is in the manufacture of cobalt driers for mixing with paints.

In electro-plating with cobalt the two best solutions have been found to be (1) cobalt-ammonium-sulphate, 200 gm. per litre of water, and (2) cobalt sulphate 312 gm., with sodium chloride 19·6 gm. per litre, and nearly sufficient boric acid to saturate the solution. From these solutions cobalt is deposited readily on all articles that are commonly nickel-plated. The solutions may be operated at a lower voltage than would be used for the standard nickel solutions to attain a given speed of plating, or with higher voltages a very rapid rate of plating can be obtained. Cobalt-plating is harder than nickel-plating, and a small quantity of cobalt will therefore afford the same protective covering as a greater quantity of nickel. The difference in the weight of the metal used more than counterbalances the higher cost of cobalt as compared with nickel, whilst the rapidity of the process also reduces the working costs.

Metallic cobalt is prepared from the oxide with anthracite as reducing agent at a temperature of about 1,000 deg. C., the final product containing no more than 0·2% of carbon. Small quantities of very pure cobalt can be obtained by heating the oxide in a current of hydrogen or carbon monoxide. By the thermit process, with aluminium powder, metallic cobalt containing not more than 0·1% of aluminium and free from carbon is obtained. Cobalt is magnetic, and its hardness is greater than that of cast-iron or cast-nickel.

Important advances have been made in the metallurgy of cobalt, and the extraction and refining of the metal do not present so many difficulties as formerly. It will be seen, therefore, that con-these are favourable to an expansion of both the production and utilisation of cobalt, an expansion which should prove profitable to the industry in Ontario."—*The Times Trade Supplement* (London), July, 1917, p. 73. (W. A. C.)

ELECTRIC SMELTING OF TITANIFEROUS IRON ORES.—"Prof. Albert Stansfield, McGill University, has recently prepared an article for the Canadian Department of Mines dealing with a big magnetite deposit in Quebec. On the north shore of the Saguenay River is a deposit of titaniferous magnetite estimated to contain from 1,000,000 to 5,000,000 tons of ore. Electric power may be obtained at two points on the river—9 miles west and 12 miles east of the deposit. Charcoal and limestone, necessary for electric smelting, are conveniently situated. The ore contains approximately 50·53% Fe, 10·55% Ti, 0·02% S, 0·03% P, and is susceptible to magnetic separation, yielding a concentrate containing approximately 56·20% Fe and 8·3 Ti, by which it will be seen that either crude or concentrated, a titaniferous magnetite must be treated. It is stated that 1·75 tons of concentrates treated in an electric furnace such as is used in Sweden would, with the addition of 0·4 ton charcoal and 0·5 ton limestone, produce 1 ton of pig iron. The electrical power required would be approximately 3,000 kw.-hours per ton of metal produced. To smelt the original ore 0·4 ton of charcoal and 0·7 ton of limestone or dolomite would be required and about 3,500 kw.-hours per ton of pig iron would be consumed. Assuming a plant to consist of three furnaces of 4,000 h.p. each and the output to be 80 tons per day, the total cost of pig iron would be about $21, and it would be marketable as an exceptionally high-grade iron."—A. STANSFIELD, *Indian Engineering*, September 1, 1917, p. 121. (J. A. W.)

ELECTRIC STEEL.—"According to the *Iron Age*, during the past three years the electric furnace has established its position as an important factor in steel production. The United States possesses 136 furnaces, nearly twice as many as a year ago, and last year their output was more than doubled, amounting to 175,000 tons. The estimated output of electric steel in Germany in 1916 was 225,000 tons. At least 88 furnaces are in use in this country, and the probable output of the world within a year or two after the end of the war is estimated at one million tons per annum. In addition to the countries named above, Italy and France are credited with 29 furnaces each, Sweden with 40, Canada with 19, and Russia with 16, while the world's total is given as 471 furnaces for the refining of steel; of these 181 are of the Heroult type, 70 Rennerfelt, 50 induction, and the remainder Girod, Stassano, Snyder, Electrometals, Greaves-Etchells, etc. The electrical smelting of iron ores is also progressing, Sweden possessing 17 furnaces of 2,000 to 4,000 h.p., with a probable output last year of 100,000 tons of pig iron."—*Indian Engineering*, Aug. 4, 1917, p. 65. (J. A. W.)

MISCELLANEOUS

WATTLE BARK INDUSTRY OF NATAL.—"The production of wattle bark in Natal was 1,300,000 cwts. in 1913, corresponding to 2,340,000 cwts. of the green, undried bark. Of this 811,000 cwts. (value £325,000) was imported into the United Kingdom for re-export and home use. Whilst the total production of Natal has naturally declined since 1913, the quantity used in the United Kingdom has increased remarkably. The most important recent development of the industry has been in the production in Natal of tanning extract. Several patents have been granted, one factory is erected and others are in course of construction. In full work, these factories will be able to deal with two-thirds of the total output of bark. In one of the patented processes the bark is simultaneously crushed between bronze rollers and extracted with hot water. In another the dried or green bark is first finely chopped, then crushed between bronze rollers, and subsequently extracted in large leaching vats. The spent bark is used as fuel."—*Journal of the Society of Chemical Industry*, May 31, 1917, p. 558. (J. A. W.)

USE AND TESTING OF OXYGEN MINE RESCUE APPARATUS.—"The value of oxygen mine-rescue apparatus is becoming more appreciated both for rescue and recovery purposes. There has been a steady growth in the establishment of rescue stations throughout the country, particularly in the Western coalfields. In training miners the Bureau of Mines teaches the use of three types of apparatus: the Draeger, the Fleuss, and the Westfalia. The bureau itself is developing a fourth type, known as the Gibbs. Each of these has a steel cylinder containing oxygen at a pressure of approximately 2,000 lb. per square inch and a reducing valve that allows a definite quantity of oxygen per minute, at a pressure slightly above atmospheric, to pass from the cylinder to a reservoir from which it is breathed by the wearer. The air exhaled by the wearer flows through to a compartment containing regenerating material, usually caustic soda (sodium hydroxide), by which the carbon dioxide in the breath is removed. The regenerated air joins the stream of oxygen from the reducing valve and is breathed again. The possibilities and limitations of such apparatus are becoming more thoroughly understood. However, during the fiscal year 1916 there were two instances of men wearing apparatus to combat mine-fires with presumably little or no previous training in its use. In another instance an apparatus party of only two men made an exploration of considerable length, and one of them lost his life. Until such practices are discontinued the dangers incident to wearing apparatus in irrespirable atmospheres will not be reduced to a minimum. Some men while wearing the apparatus fail to appreciate the fact that the added weight of the apparatus causes exhaustion more quickly than when working without it.

During the fiscal year 1916 tests were made with the four types of mine-rescue apparatus mentioned to determine the accumulation of hydrogen and nitrogen in each type when the 'oxygen' used was similar to that furnished the various rescue-cars and stations, that is, oxygen mixed with nitrogen up to 3% and hydrogen up to 1·3%. In these tests 170 samples were taken of either the original oxygen or of the air breathed by the wearers, and the tests indicated that oxygen mixed with more than 0·2% of hydrogen, or 2·5% of nitrogen, might prove dangerous for use in mine-rescue apparatus. Because of these tests the Bureau of Mines proposes, in buying oxygen for use on its cars and stations, to specify that the percentages of hydro gen and nitrogen must not exceed the figures mentioned. These tests also served to indicate the efficiency of the regenerator furnished with the Gibbs apparatus.

Because of the war in Europe the German company making the Draeger apparatus has been unable to procure regenerating cartridges from Germany for use in this country, and it has been necessary to manufacture them in America. The Bureau of Mines has tested the efficiency of American-made regenerators. Two types were submitted, one containing granular sodium hydroxide and the other containing sheet sodium hydroxide. Generally speaking, all of these generators proved satisfactory, but those containing caustic soda in sheets and having absorbent blotters in the four upper trays showed the best results; they are now being used in the training work of the bureau. Two tests were made with the Fleuss apparatus to determine whether caustic soda stored for some time in a Fleuss breathing bag was still in condition to efficiently absorb the carbon di-oxide exhaled by the wearer. In one test caustic soda stored for one month in the breathing bag was tested; the caustic soda tried in a second test had been left in the bag for two months. Samples taken at the beginning and the end of the storage period in eight inhalation-air samples taken in the course of the two-hour tests of each apparatus were analysed. The tests showed that the sodium would still act, as an inhaled air was as high as 1½%. In trials with the Fleuss apparatus, electrolytic sodium hydroxide prepared in the lump form was tested. Eight inhalation-air samples taken in the tests showed the lump solution to be an efficient regenerating agent. In four tests of the Fleuss apparatus the wearer tried the half-mask, intended for use in fire-fighting, instead of the mouth-piece. The tests indicated that although the half-mask may seemingly have an air-tight fit on a man before he enters the smoke-room, inward leakage may occur after he has been in a noxious or poisonous atmosphere for a short time, so that the half-mask is not as safe as the mouth-piece.

An important series of tests of mine-rescue apparatus was made in Colorado to determine, if possible, whether rescue apparatus possessed defects that rendered it dangerous for use at high altitudes. The first series of tests was made at Manitou, the second at the Half Way House on Pikes Peak, and the third at the summit. The results indicated that rescue-apparatus is not more dangerous at high altitudes than at low. The oxygen supply was sufficient, and, in fact, men wearing the apparatus and getting a constant supply of oxygen from it could make physical exertions of which they were incapable when breathing the natural air because of its being rarefied and containing a less weight of oxygen per cubic foot than the air supplied by the apparatus. The conclusion reached, therefore, was that the probable cause of the excessive number of accidents with rescue-apparatus in mines at high altitudes resulted from neglect in the care of the apparatus, particularly in the renewal of rubber parts that had dried and cracked. A secondary, but, possibly, more important result of these investigations was the comparison of the Gibbs apparatus with the older forms of apparatus, particularly the Fleuss and Draeger, heretofore used by the mine-rescue crews at the bureau. The results demonstrated that the Gibbs apparatus adapts itself to the wearer's needs far better than the older forms of apparatus. In endurance tests particularly it was found that this automatic adjustment tends to insure a much longer duration of the oxygen-supply and of the power to absorb carbon di-oxide than do any of the other types.

As the Gibbs apparatus, which has been developed by W. E. Gibbs, engineer of mine-safety investigations, in co-operation with other members of the Bureau of Mines, seems in several respects to be superior to other types, a detailed description is here presented. This apparatus is a self-contained unit carried wholly on the back of the user. It is light, and its parts are well protected against injury. A special device feeds the oxygen used, and although plenty is available for the wearer when working hard none is wasted when he is resting; hence the new apparatus may be worn for a considerably longer time without re-charging than other models now in use. An unusually efficient carbon di-oxide absorber that liberates little heat is another feature. Caustic soda, which is much cheaper than the potash salt formerly thought necessary, is used as the absorbent. It is theoretically easy to supply a mine-rescue man two or three hours with an artificial atmosphere from an apparatus of no greater weight than he can readily carry on his back. In practice, however, the construction and operation of such devices offer many difficulties. The knowledge that the failure of any part to respond to the needs of the wearer means his almost certain death places a heavy responsibility on the designer and constructor.

Normal air contains roughly 20% of oxygen mixed with about 80% of nitrogen and a trace of carbon di-oxide. At each inspiration part of the oxygen breathed combines in the lungs with carbon brought by the blood, and the air expired contains about 4% of carbon di-oxide. The nitrogen of the air is unchanged by the act of respiration and takes no active part in it. For all practical purposes an artificial atmosphere of pure oxygen, or oxygen containing only a small percentage of nitrogen, is actually preferable to normal air in the conditions surrounding mine-rescue work. In spite of the general belief that pure oxygen is unsafe to breathe, no abnormal effects attend its use unless it be breathed for a much longer period than that during which rescue-apparatus is customarily worn, and even then the only symptom noted is a slight irritation of the bronchial passages. The amount of oxygen consumed in the body is precisely the same whether the gas be breathed pure or diluted with nitrogen in the form of air. Contrary to the belief held a few years ago, there is no flushing of the face, no feeling of exhilaration, no increase in the pulse-rate, nor elevation of arterial tension. If, however, the oxygen-content of the air breathed be materially reduced, unconsciousness and death are almost sure to follow without any warning symptoms, provided the carbon di-oxide content of the air remains low. For this reason it is advisable that breathing apparatus should supply an atmosphere rich in oxygen. As much of the oxygen made from liquid air contains 2% to 3% of nitrogen, which remains unchanged and accumulates in the apparatus, analyses of the atmosphere breathed by the wearer generally show a decreasing content proportionate to the length of time the apparatus is worn. If the proportion of carbon di-oxide in the artificial atmosphere rises much above 2%, deeper breathing or panting warns the wearer of danger, generally in time to let him get to safety.

Under the best conditions the exploration of mines in which there has been a recent fire or explosion is a hazardous undertaking, not only because of exposure to bodily injury but also because no mechanical breathing device can be made so perfect that it will never fail. Frequent inspection of the breathing apparatus and constant vigilance in keeping it in perfect repair reduce the risk of failure to a minimum." *Mining and Scientific Press*, from the Director of the U.S. Bureau of Mines, August 18, 1917, pp. 231-236. (H. R. A.)

TESTS FOR HARDNESS OF METALS.—"An opportunity for young engineers to display their inventiveness, and, at the same time, to obtain an appreciable financial reward, has been offered by Sir Robert Hadfield, F.R.S., Vice President of the Institution of Mechanical Engineers, who has placed at the disposal of that body a sum of £200, as a prize for a description of a new and accurate method of determining the hardness of metals. The offer stands good until January, 1922, after which it will be withdrawn. The conditions provide that the Council may award the whole or any part of the sum available at any time that a communication is received, which, in their opinion, is of sufficient originality and importance in relation to the subject; or they may, from time to time, award portions of the fund, not exceeding £75 in the aggregate, in any one year, for such communications as advance the knowledge of the object aimed at even if the problem is not entirely solved. As is well known the present tests, particulars of which are obtainable in the report of the Hardness Tests Research Committee, are by no means perfect when the hardness of the material exceeds from 600 to 800 Brinell, and for metallurgical work, a considerable improvement on these methods is essential. Any communication submitted should be accompanied by explanatory scale drawings or by a model, and should reach the Secretary of the Institution, 11, Gt. George St., Westminster, at least one month before 1st January in any of the next five years. In the case of a new invention, provisional protection should be obtained before particulars are submitted." *Ind Engineering*, July 28, 1917, p. 51. (J. A. W.)

A COMPARISON OF THE EFFICIENCY OF SOME COMMON DESICCANTS.—"The methods employed by Baxter and his co-workers in determining the comparative efficiencies of $CaCl_2$, NaOH and KOH were applied to Al_2O_3, MgO and $CuSO_4$ by the authors.

Alumina was prepared by precipitating purified alum solution with NH_4OH, washing redissolving, reprecipitating, washing and finally drying at 500° C. in air dried by H_2SO_4.

Calcium oxide was prepared by precipitating the nitrate with NaOH.Aq., dissolving in HCl.Aq., reprecipitating and washing. It was then dried in the same way as alumina. Magnesium oxide was obtained in practically the same manner. Cupric sulphate was obtained by recrystallising three times from water a good grade of the vitriol, drying at 100° and heating to 100° for some time. Each of these were transferred warm to the V tube used for the experiment. The experiment consisted of passing the air through (1) aspirator, (2) 20% NaOH solution, (3) the V tube containing the substance placed in a thermostat, (4) a P_2O_5 tube weighed before and after, (5) a second P_2O_5 tube to prevent H_2O entering the apparatus.

Alumina at 25° proved very efficient, CaO soon became exhausted, MgO proved to have a very small capacity, and in the case of copper sulphate the colour indicated that the first few centimetres absorbed practically all the moisture.

The values obtained along with those of Baxter's (B) are shown in the following table, which give the weights of residual moisture in 1 litre of air at 25°, after having passed a V tube containing 30 cm. of desiccant.

$CuSO_4$	1·4 mgm water	CaO	0·2 mgm water
$ZnBr_2$	...1·1 (B)	NaOH	0·16 (B)
$ZnCl_2$	...0·8 (B)	MgO	0·008
$CaCl_2$	0·36 (B)	$Al_2O_3.xH_2O$	0·003
H_2SO_4 (95·1%)	0·3	KOH	0·002
$CaBr_2$	0·2	P_2O_5 (resublimed)	Nil

—MARY V. DOVER and J. W. MARDEN.—*Journal Amer. Chem. Soc.*, xxxix., Aug., 1917, p. 1609. (J. A. W.)

Changes of Address

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

AIMETTI, S., *l/o* Rondebosch; c/o J. H. Currie, Lindifarne, Cathcart, C.P.

BALL, CAPT. H. STANDISH, R.E., *l/o* London; Commandant, Mine School, First Army, France.

BRAZIER, H., *l/o* Johannesburg; New Modder G.M. Co., Ltd., Box 25, Benoni.

COOPER, R. A., *l/o* East Rand; Manager, Transvaal Blast Furnace, Ltd., Vereeniging.

DENNISON, JOHN A., *l/o* Johannesburg; c/o The Anglo-French Exploration Co., Ltd., 208-224, Salisbury House, Finsbury, London, E.C.

DEWAR, C. L., *l/o* Maraisburg; Consolidated Langlaagte Mines, Ltd., Box 15, Langlaagte.

GALBREATH, N. M., *to* 67, Saunders Street, Yeoville.

GRAY, CHAS. J., *l/o* Krugersdorp; Inspector of Mine's Office, Box 1072, Johannesburg.

KRIGE, W. A., *l/o* Maraisburg; Langlaagte Estate and G.M. Co., P.O. Box 98, Langlaagte.

LEONARD, D. T., *l/o* Bulawayo; Wanderer G.M. Co., Selukwe, Southern Rhodesia.

RICHARDSON, R., *l/o* Barberton; Maid of De Kaap, P.O. Consort Mine, Transvaal.

ROME, A. S., *l/o* Que Que; Wankie Colliery, P.O. Wankie, Southern Rhodesia.

SOLOMON, LIEUT. LIONEL, *l/o* Johannesburg; 177th Co., Royal Engineers, B.E.F., France.

SPANDOW, H. J., *l/o* Pilgrims Rest; Dynamite Factory, Modderfontein.

WILLIAMSON, REG., *l/o* Corinthian Mine; Bullfinch Proprietary Mine, Bullfinch, **Western Australia**.

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII DECEMBER 1917. No. 6.

NOTES ON THE SUPPORT OF THE UNDERGROUND WORKINGS OF THE MINES OF THE RAND.

By PERCY CAZALET *(Member.)*

SYSTEMATIC PACKING UNDERGROUND AT THE FERREIRA DEEP MINE.

By G. HILDICK-SMITH, B.Sc. *(President)*, and PAUL SELBY, B.Sc. *(Member)*.

(Printed in Journal, July, 1917.)

DISCUSSION.

Mr. A. J. Walton *(Member)*: After considering the method of reef packing to support the hanging wall of working stopes, as described by the authors, one is led to the conclusion that there must be some limit to the stope width to which it can be applied. Such limit cannot be very great, as considerable difficulty exists in building a good pack wall more than 7 ft. in height, and even if a wall of greater height than this is built it will collapse when pressure comes on. The usual pack, whether built of rock or timber (with the possible exception of those timber packs in which the end of the grain of the timber is employed to resist the weight) compresses very considerably before offering a great resistance, and in any really wide stope where the faces have been worked so far that in the ordinary way it would collapse breaking off at the faces, it is difficult to see how the packs would prevent it still doing so. When two stope faces are approaching each other the hanging must be in a state of strain, being bent upon the fulcrum of the remaining pillar. What are the effects of this? Dangers of falls of hanging and pressure bursts would appear to exist. From the statements of the authors we are led to believe that when reef packing is employed pressure assists the breaking, and when a stope face has stood for any time the miner is able to bar down large tonnages, so that danger of accidents from pressure bursts must be present in stopes dipping 35° or more. To minimise these accidents the stope face would probably be carried on a comparatively flat angle (by underhand stoping) thus increasing the cost of shovelling and tramming and also packing, as the reef would have to be shovelled back to fill the packs. If the stope were carried overhand then it would be manifestly dangerous for anyone to travel or work near the face on account of pressure bursts. Could the authors supply any figures to show whether accidents from pressure bursts from stope faces had increased or decreased since the method was adopted?

From the statements made in both papers the impression is conveyed that the trouble at the Ferreira Deep started largely owing to it being a large pillar of reef surrounded by worked out areas. I do not know whether this is intended, but if so, would like to call attention to the fact that trouble with the shaft was experienced many years ago, and sandfilling was started about eight years ago at the mine to overcome the difficulty. At that time there were still large blocks of ground standing East, West and South in the mine, while the Northern boundary pillar was not badly crushed. I think that the Worcester and Wemmer dikes shown on the plan are sufficient to prevent any leverage being transmitted from the adjoining properties. Several instances exist where large falls have been cut off by dikes, even though the ground on each side has been apparently equally badly supported.

It is unfortunate that the authors are unable to give any figures on the cost of the method of working, as this, and the safety of any system, are the chief determining factors in deciding its merits. If relative efficiencies in breaking and shovelling and tramming under the old and new systems could be given together with some idea as to the cost of packing and the increase or decrease in the cost of timbering, it would be useful in deciding whether or not to adopt such a system on those mines which are still able to support their hanging by other methods.

In reclamation work the authors state that footwall reef is removed after the reef packs have been withdrawn, and isolated timber packs or portions of reef packs are left to support the hanging. By this time apparently sufficient crush has taken place to make these supports practically as compact as the original reef, and presumably islands of footwall reef are left under these supports, which then become for all practical purposes pillars. Do these pillars ever crush, and are they ever removed? If so, it would be interesting to know how this is done without running considerable danger in the work.

One question arises in connection with the system which I find it difficult to answer, viz., if the timber packs put in to support the hanging during the removal of the reef packs are sufficient, why pack reef at all? It would seem at first sight to be much more economical to put in good timber packs well filled with waste, even if the waste had to be quarried out of the footwall, as this is evidently one of the chief forms of support employed during the period of removing the reef packs when the greatest danger from falls of hanging would appear to exist.

Mr Cazalet suggests that the ideal method of working would be to reach the boundary first, and work home if it were not for financial difficulties, but this point has so often been suggested and so seldom tried that one doubts if, apart from financial difficulties, it would be successful.

In a report of the Mine Manager's Association it is stated that for economical working not less than 50 ft. of face should be provided for each machine, and if an efficiency of 10 tons per machine shift is assumed it would mean that for a deep level mine raising 100,000 tons per month on a 25 working day month, 20,000 ft. of working face would be required to give the necessary output. A safe margin of probably 50% would be required, as no doubt difficulties would arise with the ends of levels approaching the face when sudden weights came on, and to allow for crossing faults, so that 30,000 ft. of face lying almost in the line of dip would be required, and further, if 25% of the ground proved unpayable the face available would have to be further increased to 37,500 ft. The difficulties of concentrating any reasonable tonnage on levels would be almost insuperable, and to obtain such a face would be practically impossible on most mines of the Rand, both owing to faults and the shape and size of the mine properties. If such a face were obtainable reclamation would become very difficult, except in the immediate vicinity of the face, and reef packing would be entirely out of the question, as the natural object of such a system would be to have no old workings and levels to maintain.

The supply of mine timber may become one of the great difficulties of the future, but it is difficult to believe that it will be so. Ordinary blue gum is a very quick growing timber, and several mines have adopted the sound policy of growing their timber for underground work. The uses to which it can be put are very limited, so far as work on the surface is concerned, and therefore the law of supply and demand should operate and prevent the price being raised unduly.

Sandfilling, applied in conjunction with timber packs, should not prove a very costly operation, and once an area has been mined and again filled in this way the roads through it should stand without repair indefinitely. The cost of a sufficient number of timber packs filled with waste rock should not be excessive and, no doubt, many areas when supported this way would require no further support, as any local caving would not necessarily affect the main roads, which could be further supported by means of sand packs. Reef packing can apparently only be applied within limited angles of dip, while filled timber packs have not necessarily any such limit. The point that solid pillars do not sufficiently support the hanging in any, except comparatively shallow mines is generally admitted, and even if they are of large dimensions pressure bursts are liable to occur. These can to some extent be minimised by housing the pillars with timber bound with old ropes, but eventually the old ropes will break and the pillars fall out.

Where several reefs in close proximity to each other have to be mined the position is one of some difficulty, especially in an old mine where development has not been too well done and the valuation of the reefs is indefinite. On the deeper mines with such conditions one method would be to value the reefs as well as possible, mine the bottom payable reef first, and support the space thus made by timber and waste rock packs, afterwards filling the space with sand, and follow up with each succeeding reef in like manner. Natural conditions still make it impossible to treat some areas in this way, and then one is led to the conclusion that the proper thing to do is to mine the top reef first, sandfilling being impossible, and make sure of having a solid footwall from which to support the hanging of each reef. Conditions are possibly more difficult where the partings between reefs are so narrow as to be almost negligible—conditions which are not very uncommon in parts of the Germiston district. Mining here is, of course, a simple enough proposition where the depth is not great and the pillars, which can later be recovered with the assistance of sandfilling, will support the hanging; but given a width of 25 ft. to 30 ft., timber is almost useless, and even at comparatively shallow depths pillars have to be of large dimensions, it being no uncommon thing for such pillars to contain over 2,000 tons of ore. What will be the position if such reefs are found at great depth, and how are we to work a stope 25 ft. in width? To mine the whole face at once is almost impossible, provided we acknowledge that pillars will not stand; to mine the bottom portion first would produce a treacherous hanging of reef, while if the top portion is first mined reclamation has to be conducted under a moving hanging. There seems to be little danger in mining the top portion first provided systematic packing is resorted to and the hanging allowed to subside on to the packs. In this case what would be the stope width in the first working? I think the limit would probably be about 10 ft., and then it is questionable whether it would be safe to retreat, taking both the reef packs and the footwall reclamation on the way. Can the hanging be made to subside on the packs without breaking? If so, the operation would be comparatively simple, and the whole object of mining—to obtain all the payable ore safely and at a reasonable cost—would be attained. This method could only be applied where the dip is probably not more than 35°, but what are we to do with great stoping widths at greater angles than this? Reef packing seems to offer little assistance with such a proposition.

FERTILISERS.

(Printed in Journal, November, 1917.)

By ALLAN BAGULEY, B.Sc., F.I.C.

DISCUSSION.

Dr. C. F. Juritz (*Agricultural Research Chemist*) contributed: If everyone either directly or indirectly interested in South African agriculture were thoroughly to familiarise himself with Mr. Baguley's aphorism that "fertilisers may lead to infertility," a great advance towards a rational system of manuring would be made. It would then be better realised that similar crops on different soils need different fertilisers; that brack soils should not be given fertilisers which increase their brackness, nor sour soils be dosed with fertilisers that augment their acidity; that some manures, unless diluted before being put on the land, may burn your germinating crop, and that stimulating or forcing fertilisers if continually applied, will leave the soil poorer than they found it. Disregarding these principles, one may be constantly adding fertilisers to the soil, and, by that very addition, rendering it less productive and possibly even infertile. I fear, however, that precisely in this way many a South African agriculturist has been blundering along, and, if many have not brought their soils quite to infertility, this has been often due to good fortune rather than good management. Mr. Baguley himself has referred to the harm that may be done by nitrogenous fertilisers inconsiderately applied. Our valuable government guano is often misused in this way, and undiluted allowed to burn root systems with which it comes in contact when it might have benefited them greatly if applied mixed with three or four times its bulk of earth. Wrong and excessive use of Karroo ash may cause brack, and gypsum may hasten soil exhaustion, and so we realise how needful it is that one should "manure with brains." Mr. Baguley in his remarks has repeatedly shown how manuring without knowledge or circumspection may injure both crop and soil. But I am not going to enlarge on these points, nor on the fact, also touched on by Mr. Baguley, that productivity depends on a number of factors, of which the chemical composition of the soil is only one. I sometimes think that persons interested in agriculture are divisible into two classes: the extremists of one class look on the chemist as a sort of wizard who, after subjecting a few grains of soil to chemical analysis, can straightway tell what sort of crops an entire district is fit for, irrespective of all considerations regarding the physical structure and texture of the soil, its colour and density, its thermal capacity, capillarity and water power, the presence or absence of bacteria and protozoa, the slope and aspect of the land, the general topography and meteorology of the area concerned. This class of person, strange to say, one finds more frequently amongst than outside of the farming community: but there is another class, a very superior sort of person, who knows all there is to be known about farming from the *dilettante* point of view. These people are very fond of keeping the chemist in his place, and never tire of telling him—what he knows full well—that there are many things outside of chemistry that affect a soil's productiveness. They are obviously right when they assert that chemistry is only one of the links in a chain of many links, but when they imply that on this account the chemical link may be safely neglected their lack of logic is patent.

I am not in the least disregardful of the vast importance of soil physics, soil bacteriology, and lysimetry or the measurement of water movement in soils, but each in his own order, and my business here and now is to refer solely to chemical questions, hence I do not propose to go further than these in my remarks on Mr. Baguley's paper.

Mr. Baguley spoke of the dangers of water-soluble fertilisers, and of the failure of the rain to carry away objectionable substances. On the other hand, however, the rain often carries away these soluble fertilisers themselves, and so the farmer suffers less. It so happens that by far the greater quantity of fertilisers applied to the soil, in the Cape Province at least, is water soluble.

Mr. Baguley was quite right from a South African standpoint in putting phosphoric acid first in order of importance—may I just interpose the remark that the statutory term laid down in the new Fertiliser's Act of the Union (No. 21 of 1917) is "phosphoric *oxide*." It is the constituent which, above all others, is needed for cereal production, and especially for wheat. He is also right in giving the second place to nitrogen. One difference between these two plant food constituents is that phosphoric oxide, if it does not occur naturally in the country, must be imported, whereas nitrogen will sooner or later be brought into the soil from the atmosphere, ultimately by means of one or other of the nitrogen-fixation processes instituted of late years, but in the meanwhile, I hope, by an increased employment of nitrogen-fixing crops. A much larger use of kraal manure is now being made than formerly, but the supply is not inexhaustible, and other sources of nitrogen will have to be tapped, or we shall have to cease growing cereal crops. And so we come, in the first place, to the catch crops of which Mr. Baguley spoke. The crop generally employed for such purposes is clover, but here we meet with one of those factors other than chemical that have to be considered in the growing of crops. South African meteorology is such that parts at least of the country are denied facilities which are the commonest perquisites of other lands. In the cereal lands of the South-West clover cannot be grown without irrigation at just the time when it would be needed to serve the purpose of a green nitrogenous manure. I believe, however, that Mr. C. Leonard has had excellent results in the Caledon Division by growing the spring vetch as a nitrogen-collecting crop for cereals. Then Mr. Baguley referred to the refuse of abattoirs. I think we utterly fail to realise the waste of fertilising materials that continuously goes on. If all the waste material from slaughterhouses all over the country were collected and turned into fertilisers, many thousands of pounds sterling would be saved. Dried blood is one of the most valuable nitrogenous fertilisers that we possess: I heard the other day of a lady in Maritzburg who regularly sends for a bucket of blood, which she pours round her fruit trees. But some abattoirs that I know of have been specially constructed so as to carry all their blood into the sea.

Mr. Baguley also alluded to the refuse of fisheries. Here one thinks principally of our whale and crayfish industries. Farmers have a prejudice against the use of fertilisers prepared from whale meat or crayfish because of the slowness with which such fertilisers become available to the crops. This is mainly due, apparently, to the fatty substances which whale or crayfish fertilisers contain, and endeavours are being made to extract as much as possible of this fat or oil, and use it in other industries, leaving the residue a better fertiliser than before.

The reference made to mineral phosphates is very opportune. I noticed some months ago that farmers were told in a lecture that rock phosphates had given good results in America, the inference being that what they had done there they could do here. But it must be remembered that there are rock phosphates and rock phosphates: Fletcher, for instance, points out that the phosphoric oxide in Florida rock seems to be much more slowly available than that in South Carolina rock. The former is mainly calcium phosphate, while the Florida soft rock is mainly aluminium and iron phosphate, and to this extent resembles the Saldanha Bay deposit: ("Soils," 1907, p. 381). It is, therefore, well that Mr. Baguley indicates that the largest South African deposits of which we know are radically different from the mineral phosphates which the Australians and the Japanese convert into superphosphates. Mr. Baguley mentions three methods of utilising these deposits of ours, but adds rightly that research is required in this direction. If our aluminium phosphates are to be used at all in their raw condition it is clear that they must be exceedingly finely ground. I am inclined to hope that they may then be found to act after some reasonable time upon our phosphate-lacking soils, but, as Mr. Baguley says, the matter needs research, and so plot experiments are now being carried on at Elsenberg and elsewhere.

I agree with Prof. Hopkins that raw rock phosphate may possess more value than we usually ascribe to it: but even Prof. Hopkins says that raw phosphates should not be expected to give marked benefits except when used in connection with adequate supplies of decaying organic matter, and in comparing Saldanha Bay phosphate with Florida soft rock one difference in chemical composition must not be lost sight of. According to Fritsch ("Manufacture of Chemical Manures," 1911, p. 31), the latter may contain as much as 2·05 of phosphoric oxide soluble in Petermann's ammonium citrate solution, whereas the Saldanha Bay phosphate does not contain any appreciable quantity of this soluble phosphoric oxide. Hence it is not quite fair to argue that the latter rock is very similar in chemical nature to that from Florida, and that we may therefore expect increased crops from its use. It is our bounden duty to experiment, and we may go as far as to hope, but until we have satisfactory results we ought not definitely to expect them. The Alta Vela and Redonda phosphates resemble ours more nearly. They are used, according to Fritsch (*op. cit.*, p. 161) by fusing them, after grinding, with "super acid" ammonium sulphate, and adding a further quantity of ammonium sulphate. A fertiliser results containing 7 of nitrogen and 13% of phosphoric oxide, of which 11 is water soluble.

Mr. Baguley's remarks suggest many other lines of thought, but I fear that I have already exceeded my limits. Remarks on fertilisers are all the more timely just now, when our legislature has recently extended the principles of the Cape Fertilisers Act to the whole Union. A friend of mine in the Cape told the farmers the other day that the Cape Act laid no restrictions on the fineness to which bones should be ground if sold as fertilisers. Such a statement gives a wrong impression, for the Act itself was merely the framework on which all the regulations (in force since 1908), which were its pith and substance, were suspended, and those regulations provided that bone meal or bone dust must contain at least 80% of material capable of passing a sieve of eight meshes per linear inch. I mention this to show how requisite it is that all interested in farming should become conversant with the provisions of these regulations.

As the regulations dealt with other requirements, which will probably soon extend to the rest of the Union, some of them may be briefly referred to ere I close my remarks. Loose statements covering a range of percentages were prohibited by them, and merchants were required to confine themselves to single definite figures, and to apply them only to nitrogen, phosphoric oxide, potash, and lime, and not to their compounds. The result was that in-mixed fertilisers being labelled as:

	Per cent.
Sulphate of ammonia	23—25
Potash salts	90—92
Superphosphate	26—28,

they had to be advertised and invoiced as respectively:—

	Per cent.
Nitrogen	4·8
Potash	18·6
Phosphoric oxide (water soluble)	11·96

Of course, as comparison of the two sets of figures shows, the advertisement loses a great deal of its glamour but the descriptions represent the facts more accurately to the farmer. But it is not enough merely to state the *percentages* of nitrogen, potash, and phosphoric oxide in a fertiliser. It means all the difference in the world to a farmer whether the nitrogen in a mixture comes from nitrate of soda or from leather, whether the potash is furnished by kainit or by powdered felspar, whether the phosphoric oxide is in the form of dissolved bones or is merely crushed phosphate rock. In one case he has a fertiliser of considerable value, in the other it is almost valueless, and so the regulations insist on the *sources* of the ingredients being stated.

Another regulation of importance, is that fertilisers must be true to name, and the use of certain names is restricted: thus the term "guano" may be applied only to articles of defined origin, and in some cases not even then unless preceded by a qualifying adjective, whilst the removal of nitrogenous constituents from the guano results in its name being changed from "guano" to "guano phosphate."

The regulations provide for the provision by fertiliser vendors of invoices showing the chemical composition of the article sold. I fear, however, that many farmers purchase their fertilisers by name rather than by composition. A clear proof of this is the fact that one brand of fertilisers sometimes embraces a dozen or more differently named articles, like "sugar cane fertiliser," "coffee fertiliser," "vine fertiliser," all with the same composition.

But I must not inflict myself any longer, so I shall close with a word of thanks to Mr. Baguley for his timely and useful contribution.

Obituary.

Mr. George T. Holloway

It will cause much regret to members to learn of the recent death of Mr. George Thomas Holloway, for many years one of our Corresponding Members of Council, as notified in the London *Mining Magazine* for November, 1917.

Mr. Holloway had suffered from impaired health for some years, but the news of his decease comes as a great shock to his many friends. His arduous labours since the outbreak of the war for the development of the nickel industry in the national interest have recently received a fitting memorial in the shape of the publication of the bulky 700-page Report of the Royal Ontario Nickel Commission, of which he was for two years Chairman. This report has resulted in the establishment of a large nickel-refining plant in Ontario at Port Colborne on Lake Erie for dealing with Sudbury and other nickel-copper mattes, and the production therefrom of metallic nickel. These mattes were previously refined in New Jersey, U.S.A.

Mr. Holloway was engaged for many years in practice as an assayer of high repute in London, and likewise controlled a metallurgical testing plant at Limehouse, London. Besides being a Fellow of the Institute of Chemistry, the Chemical Society and many other scientific societies, he was an Associate of the Royal College of Science, Vice-President of the Institution of Mining and Metallurgy, Examiner for the British Board of Education, and Juror in the Franco-British Exhibition in 1908.

His contributions to the proceedings of the Societies to which he belonged, especially the Institution of Mining and Metallurgy, were numerous and noteworthy.

He was professionally consulted by the Transvaal Chamber of Mines in regard to the osmiridium occurring in banket ore, and also the possibility of developing a zinc-smelting industry in the Transvaal.

His kindly unassuming nature endeared him not only to his students, but likewise to his numerous friends engaged in metallurgical and mining work all over the world including many on the Witwatersrand, to whom he was delighted to afford hospitality and information when they visited London. It may be fittingly said of him that men of his high character and conduct do much to raise and maintain the status of the profession of which he was so distinguished a representative.

W. A. C.

Mr. W. Laurie Hamilton.

The death is recorded of Mr. W. Laurie Hamilton, who passed away after a long illness on December 18th.

Mr. Hamilton, who had been a resident on the Rand for about 29 years, was for a number of years Consulting Engineer to Barnato Bros., subsequently joining the Rand Mines Group as Manager for some years of the Rose Deep, Ltd. Latterly Mr. Hamilton had been practising as a Consulting Mining Engineer. He joined the Society as a member in August, 1897, and made several interesting contributions to discussions. The funeral, at Braamfontein on the 19th, was attended only by intimate friends of the deceased, to whose wife and relatives the condolences of the Society are extended.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Testing of Galvanised Iron.—"An examination was made of the different methods which have been introduced for the estimation of zinc on galvanised iron. On account of the non-uniformity of the coating, which was found to lead to variations amounting to 12·3% in the thickness of the coating on different parts of a plate, it was found desirable that estimations should be made with samples at least 15 cm. × 15 cm. square. The use of sodium hydroxide as a solvent for the zinc is unsatisfactory. The method in most general use measures the time necessary for removal of the zinc by immersion in neutral copper sulphate solution, but has the disadvantage that the zinc does not dissolve at a constant rate since the coating is not homogeneous and the zinc-iron alloys in the lower layers are less electro-positive than the pure zinc. A misleading result is thus given by the fact that alloyed iron diminishes the rate of solution of the zinc in the copper sulphate, but increases its rate of corrosion when exposed to the atmosphere. The zinc layer can be removed by means of neutral lead acetate, but in order to remove the alloy layers, it is necessary to use a large excess of the lead salt. More uniform and complete removal of the zinc is obtained by hydrochloric acid solution, preferably of a concentration of 19·5% acid (sp. gr. 1·098 at 15° C.). The temperature should not exceed 45° C. during the reaction. The plate is immersed until effervescence ceases, then washed, dried, and weighed. Comparative estimations showed that the amount of iron dissolved by the hydrochloric acid solution was constant in different determinations and slightly greater than that removed by lead acetate solution, on account of incomplete solution of the zinc iron alloys with the latter solvent. On treating galvanised sheets with a solution of hydrochloric acid (10·5%) it was found that during the first minute the amount of iron which passed into solution was 0·65% of the total metal dissolved and could be accounted for by the initial contamination of the molten zinc used for galvanising. After 3 minutes 91·2% of the total zinc and 24·2% of the total alloyed iron was dissolved. During the next 3 minutes, 8·22% more of the zinc and 65·38% more of the iron dissolved. During the following 4 minutes only 0·53% of the zinc and 10·42% of the iron was dissolved. The large increase in the ratio of iron to zinc dissolved in the later stages would indicate that in addition to alloys like $FeZn_{[illegible]}$ and $FeZn_{[illegible]}$, there may be a series high in iron and low in zinc such as $Fe_{[illegible]}Zn$ and $Fe_{[illegible]}Zn$. During the dissolving of the outer coating of almost pure zinc, the curve showing the relation of the rate of solution with time is nearly a straight line which bends very sharply when the layer of alloy is reached. An estimation of the duration of this first period and the amount of iron dissolved gives a measure of the purity of the outside coating of zinc and the thickness of the layer, which are the two factors determining the capacity of the sheet to withstand corrosion."—J. C. Witt.—*Journal of the Society Industry*, May 31, 1917, p. 553. (J. A. W.)

Detinning and Analysis of Tin Plate.—"An investigation was made of the different methods of analysing tinned iron plates. By dissolving the tin in hydrochloric acid and titrating with iodine, a mean value of 0·089 oz. of tin per sq. foot of surface was obtained. By the method of repeated immersion in boiling sodium peroxide solution, followed by acidifying with sulphuric acid, a higher average value of 0·105 oz. per foot was obtained, the difference representing the amount of iron removed with the tin. That this iron was part of the alloy and not due to attack on the base was shown by the fact that there was no further loss in weight on subsequent treatment with sodium peroxide. The most rapid and accurate method of determination was found to consist in arranging a section of tin plate, 5 cm. × 5 cm. square, as anode in a 30% sodium nitrate solution and electrolysing with a current of 0·7 amp. The tin is completely removed within 10 minutes, and the iron of the alloy is left in the bath and can be readily determined by recovering as ferric hydroxide, while the iron of the base is left unattacked. An average value of 0·105 oz. tin per sq. foot was obtained by the use of lead acetate in presence of sodium or potassium hydroxide, when the tin is rapidly dissolved and lead deposited in a spongy condition. After immersion for 5 minutes, the average value found was 0·098 oz. tin per sq. foot, and after 3 days, 0·105 oz. Lead nitrate in neutral or acetic acid solution has no action on tin plate. Chromium, aluminium, and copper salts in presence of alkali have a similar solvent action on tin, though the solution is slower and less complete than with sodium plumbite. Concentrated nitric acid will remove tin without attacking the iron base. Estimates of the iron present as alloy in the tin coatings in the samples analysed gave a value of about 15% of the weight of tin."—G. W. Heise and A. Clemente.—*Journal of the*

Society of Chemical Industry, May 31, 1917, p. 553. (J. A. W.)

PALLADIUM GOLD CRUCIBLES AS PLATINUM SUBSTITUTES.—"An alloy of palladium and gold known as 'Palau,' which has been prepared as a substitute for platinum, has the surface colour of pure palladium and is similar to, but slightly darker than, hammered platinum. Tests at the U. S. Bureau of Standards showed that a crucible formed of the alloy is not so easily deformed as one of pure platinum though not so rigid as a crucible made of platinum with about 8–10% rhodium. The sp. gr. of the alloy is 17·22 and the melting point 1370° C. The E.M.F. against pure platinum is 8·5 millivolts at 960° C. and 7·2 millivolts at 860° C. A crucible of the alloy was heated to 1200° C., in a furnace free from metal vapours, for two periods of 4 hours each, and weighed before and after each heating. The weighings to determine the loss due to heating were followed by treatment for 5 minutes with boiling hydrochloric acid (1 HCl to 1 H_2O) and the loss in weight due to the acid treatment was determined. The solutions obtained from this crucible contained less than 0·01 mgm. of iron. The tests indicated that the 'Palau' crucible, as far as resistance to loss on heating to 1200° C. is concerned, is superior to platinum containing about 2·1% iridium. The comparative freedom from iron is an improvement over most platinum ware now in use. The alloy compares favourably with platinum in resistance to hydrochloric, nitric, hydrofluoric, and sulphuric acids, ferric chloride and sodium hydroxide solutions, and fused sodium carbonate. The 'Palau' crucible is not as suitable for potassium pyrosulphate fusions as platinum. Both this alloy and platinum are seriously attacked by fused sodium carbonate and nitrate mixture, though the 'Palau' crucible is the more resistant."—*Met. and Chem. Eng.*, 1917, *16*, 533.—*Journal of the Society of Chemical Industry*, June 30, 1917, p. 670. (A.W.)

FUSED SILICA.—"Numerous attempts to fuse and work quartz or other forms of silica have been made during the last seventy years, but the experiments up to 1900 were chiefly of academic interest.

In 1901 Shenstone read a paper before the Royal Institution, in London, giving the result of his experiments in working quartz by means of an oxy-hydrogen blow-pipe, and gave details of a practical method of producing articles of fused quartz from rock crystal. Shenstone's method consisted in fusing a number of small fragments of crystal together to form a rough rod by means of an oxy-hydrogen blowpipe, and this rod was heated and drawn out into a thick thread. A number of these threads were bound together round a thick platinum wire and the individual rods fused together so as to form a tube. This tube was then drawn out, closed at one end, and shaped by blowing as is done in working glass, except that the quartz has practically to be worked in the blowpipe flame itself. Shenstone exhibited many articles which showed great manipulative skill in their manufacture.

At the fifth International Congress of Applied Chemistry, in 1903, Dr. Heraeus read a paper on fused quartz, giving the results of his experiments in fusing this material and producing articles of transparent silica.

The methods of both Shenstone and Heraeus were developed commercially, but were so expensive that large scale working was out of the question on account of the high price of pure rock crystal and the cost of using the oxy-hydrogen blowpipe. The attention of workers was therefore turned to the possibility of fusing silver sand, which contains over 99% silica, and to the adoption of electrical methods for fusing the material.

The difficulties in fusing quartz are due, firstly, to its very high melting point, secondly, to the fact that the melting point and vaporising temperatures lie very closely together, and thirdly, because there is no material sufficiently refractory to act as the containing vessel in which it can be fused, nearly all materials reacting with silica at the fusion temperature.

In the first experiments carried out at Wallsend in 1903, attempts were made to obtain a mass of molten quartz or sand in a liquid state and to work it much in the same way as glass is worked, but it was soon discovered that this was out of the question.

Although it is very difficult to get silica really fluid, it can be got into a plastic condition much more readily, and after a large amount of experimental work had been done, methods were evolved for working it in this condition.

The type of furnace employed is an electrical resistance one, the heating core or resistance consisting of plates, tubes, or rods of carbon or graphite. The limits within which such furnaces can be worked are exceedingly narrow because the temperature at which silica reacts with carbon to form carborundum is very close to the temperature required for working silica. The electric furnace, however, renders it possible to control the temperature of fusion, as accurate measurements are relatively easy.

In the manufacture of tubes or pipes the starting point is a hollow cylinder of plastic silica; this is formed by fusing a mass of sand round a central core through which the current is passed. The size of the cylinder is of course decided by the amount of electrical energy passed through the core and the length of time the heating is continued. As soon as the hollow cylinder has been formed the heating core is withdrawn from the centre of the mass, which can then be removed from the furnace and drawn into tubing. If a moulded article such as a pipe is required, the hollow plastic cylinder is closed at one end by mechanical pressure and a refractory nozzle, to which a source of compressed air is attached, pressed into the other end; the fused mass is then placed in the mould and expanded with compressed air till it assumes the required shape. The weight of fused material which can be worked at the present time exceeds 200 lb., and it is interesting to compare this with the small blowpipe pieces which were made by Shenstone and Haraeus in 1902. The temperature required for fusing silica is between 1,800° to 2,000° C. In the plastic condition it is extremely ductile and can be drawn out like glass in lengths of 90 ft. to 100 ft.

The material made by the process I have described is rough on the outside, but small laboratory ware is subjected to a further process of grinding and finally glazing by melting the surface. This may be done electrically or by an oxy-hydrogen blowpipe.

Unfortunately owing to the extreme viscosity of plastic silica it is very difficult to remove the fine air bubbles which are found mixed with and contained in sand, and this has so far prevented the material made from sand being entirely transparent, though very great improvements have been, and are still being, made in this direction. The lustrous appearance of some of the material is due to reflection from the included air.

The specific gravity of fused silica made from sand is 2·07 as compared with 2·2 for the material made from rock crystal. The co-efficient of expansion of the two materials is practically the same, viz., 52×10^{-8}. A rod 1 metre long heated from 0° to 1,000° C. expands 0·5 mm.

The properties of fused silica are now generally well known. Fused silica is unattacked by practically all acids except hydrofluoric acid and phosphoric acid above 400° C., and at the same time on account of the very small co-efficient of expansion it is able to resist extreme changes of temperature without cracking. These properties make it of great value for the manufacture of chemical plant.

Typical arrangements of plants for the concentration of nitric acid, concentration of sulphuric acid and denitration of mixed acids from the manufacture of trinitrotoluene are given.

In addition to these uses there are many others for the material in the chemical and other industries, such as condenser pipes in the manufacture of hydrochloric acid and as basins, etc., for concentrating phosphoric acid, but to put it generally, fused silica is of value in all cases in which heat-resisting and acid proof qualities are of importance.

It is now very largely used for laboratory articles of all sorts, especially for combustion tubes for determining carbon in steel, pyrometric work, etc. In the gas industry I think fused silica will be found to be a valuable material and lead to much greater efficiency, as on account of the high temperature which it stands it is possible to make all gas lighting cylinders and globes of fused silica much smaller than can be done with glass, which enables a high mantle temperature to be employed and a corresponding increase of light attained. The want of absolute transparency in the material is not a disadvantage as it renders the light pleasanter to the eyes and gives a more equal diffusion.

Fused silica is already being largely used for electric heating apparatus, and on account of its valuable insulating properties which are retained at relatively high temperatures, and to the fact that it is not hygroscopic in the same way as glass and china, it makes a very efficient insulator."—F. Bottomley.—*Journal of the Society of Chemical Inustry*, June 15, 1917, p. 577. (J. A. W.)

CHEMICAL EXAMINATION OF NATURAL BRINES.—"The following determinations are recommended: —*Deposit on aeration.*—The sample is allowed to stand, with occasional shaking, for two or three days to aerate any iron compounds present. The height of the liquid in the bottle is marked and the whole is filtered and the deposited matter is washed (the washings being kept separate), dried, and ignited to constant weight. The volume of the sample is measured by ascertaining the capacity of the original container. The *specific gravity* of the filtered brine at 15° C. is determined by the Westphal balance. The sp. gr. of the fresh brine is different from that of the sample after several days. *Total solids* are determined on 25 cc. of the filtered sample; the residue is dried at 160° C. *Silica* is separated in the usual manner, and the residue is treated with sulphuric and hydrofluoric acids and the loss of weight reported as silica. The residue is added to the iron and alumina precipitate. *Iron and alumina* are estimated by precipitating with ammonia from the filtrate and washings from the silica. A separation of the iron and alumina is seldom required. *Calcium.*—The filtrate from the iron and alumina is diluted, and the calcium precipitated as oxalate and ignited to oxide. Its amount is checked by dissolving it in dilute sulphuric acid and titrating with potassium permanganate. The calcium should be reported as sulphate and chloride. *Magnesium.*—The combined filtrates and washings from the calcium are acidified with hydrochloric acid, and the magnesium precipitated with sodium hydrogen phosphate, ignited to $Mg_2P_2O_7$, weighed, and calculated to bromide and chloride. *Barium and strontium* should be looked for in the absence of sulphates. They are partially precipitated with the calcium and magnesium. When the proportion of barium and strontium is low, they may be neglected. *Ammonia* is seldom present in commercially important proportions. *Sulphuric acid.*—The barium sulphate precipitate is filtered, washed, and ignited in a porcelain crucible. It is then dissolved in a few cc. of warm concentrated sulphuric acid and poured into 250 cc. water, allowed to stand and then filtered, washed, ignited and weighed. (This method of purifying the barium sulphate is very effective.) The sulphuric acid is reported as calcium sulphate. *Potassium and sodium.*—The filtrate from barium sulphate is used for determining the potassium and sodium, by the method described in 'Mineral Waters in the U.S.A.,' Department of Agriculture Bulletin 91. They are reported as potassium and sodium chlorides. *Chlorine* is estimated by titration with silver nitrate solution. The bromine value must be deducted. *Bromine* is liberated by treatment with chlorine and its amount determined colorimetrically. The bromine should be reported as magnesium bromide as it is so considered by the trade, but any free bromine should be reported as such."—O. R. Sweeney and J. R. Withrow, *J. Ind. Eng. Chem.*, 1917, *9*, 671-674.—*Journal of the Society of Chemical Industry*, August 31, 1917, p. 924. (J. A. W.)

SOLUBILITY OF CALCIUM PHOSPHATES IN CITRIC ACID.—"Numerous analyses were made of samples of calcium phosphate of commerce and of the same substance prepared by the methods usually recommended. It was found that the substances sold as 'phosphate of lime' and 'calcii phosphas B.P.' were mixtures of di- and tri-calcium phosphates. Disodium phosphate added to ammoniacal calcium chloride, and bone ash dissolved in hydrochloric acid and precipitated with ammonia, both yield mixtures of di- and tricalcium phosphates and calcium hydroxide. When three equivalents of lime are made to act on one equivalent of phosphoric acid and the precipitate is filtered off at once, pure tricalcium phosphate is obtained; but when two equivalents of lime are used, the product is a mixture of di- and tricalcium phosphates. With regard to solubility in the prescribed 2% citric acid solution, it was found that 91 of the total phosphoric acid in pure tricalcium phosphate was available after 30 minutes shaking, but that the addition of calcium carbonate reduced the solubility to 84%. Extraction with the citric acid solution is not an exact criterion of the availability of the phosphoric acid, since the availability was reduced from 91% to 84.5% by the addition of 14% of lime as carbonate, and to 84.3% by addition of a further 14%. The citric acid is a solvent for the lime rather than the phosphoric acid, since all the lime not present as tricalcium phosphate is extracted. Dicalcium phosphate is soluble in the citric acid solution, so that it is not possible to distinguish between the di- and tricalcium phosphates by this solvent, and therefore the use of citric acid as indicating the manurial value of phosphates is questionable."—A. A. Ramsay, *J. Agric. Sci.*, 1917, *8*, 277-298. *Journal of the Society of Chemical Industry*, August 31, 1917, p. 933. (A. W.)

Determination of Phosphoric Acid in Phosphate Rock. "From ½ gm. to 1 gm. of the phosphate rock is decomposed by means of nitric and hydrochloric acids, and the silica is removed by evaporating twice to dryness in the customary manner. The dried mass is taken up by 10 cc. of concentrated hydrochloric acid and after dilution with boiling water, the solution is filtered from the insoluble matter, and the latter is washed until the bulk of of the filtrate and washings measures 175–200 cc. Ammonia is added, with constant stirring, to this filtrate until a gelatinous precipitate of calcium, iron, and aluminium phosphates begins to form, and then 30 cc. of ammonia solution (sp. gr. 0.9) is added in excess and the whole stirred vigorously: 10 cc. of a saturated solution of citric acid is now added, and the solution is stirred for two minutes, at the end of which time, if the precipitated phosphates have not redissolved, more citric acid solution is added, drop by drop, until the phosphate solution is quite clear. 30 cc. of the magnesium mixture is now added, and the solution is stirred until the precipitate of magnesium ammonium phosphate begins to form: after standing for three hours it is filtered. The volume of citric acid required to clear the solution is proportional to the amount of phosphoric acid present in the liquid, and by use of a solution of citric acid of known strength for this purpose, an approximate idea of the strength of the sample may be obtained. The results agree closely with those obtained by the molybdate method."—C. C. Semple, *Eng. and Min. J.*, 1917, *103*, 1110-1111.—*Journal of the Society of Chemical Industry*, August 31, 1917, p. 933. (A. W.)

Granular Calcium Chloride as a Drying Agent.—"Air containing a known amount of water vapour was aspirated over a long column of anhydrous granular calcium chloride and the residual moisture absorbed and weighed in a glass-stoppered phosphorus pentoxide tube. The calcium chloride had been previously dried at 200–275° C. in a current of air dried over phosphorus pentoxide. A tube 100 cm. long and 2 cm. diam., filled with the dry calcium chloride and kept at 25° C., removed at a rapid rate (9 litres per hour) the whole of the weighable moisture from a fairly large volume of air (40 litres) saturated with water vapour at 25° C. The amount of air that may be dried at maximum efficiency decreases as the rate of passage increases but not in the same proportion, the rate at 23 litres being about half as great as at 5 litres per hour. Experiments showed that the efficiency of a calcium chloride drying tube depends upon the volume of gas and the rate of flow rather than on the amount of moisture in the gas, and that granular calcium chloride when absolutely dry will remove every trace of moisture from a gas passed over a sufficiently long column of it."—A. T. McPherson, *J. Amer. Chem. Soc.*, 1917, *39*, 1317-1319. *Journal of the Society of Chemical Industry*, September 15, 1917, p. 951. (J. A. W.)

The Refractory Properties of Silica. "The reputed melting point of kaolin (1700° C.) is the same as that of silica, but is really the temperature at which the clay can just sustain a load of about 1 gm. per sq. cm. If the material is loaded with 10 kilos. per sq. cm., its melting point will be 100° C. lower. Silica, on the contrary, has a true melting point which is independent of the pressure, and shows no appreciable softening. The pressure required to crush an article made of silica decreases progressively with increased temperature as shown by the following results on a 'Star' (U.S.A.) silica brick: 15° C., 170 kilos. per sq. cm.; 520°, 158; 670°, 150; 800°, 139; 950°, 125; 1050°, 120; 1200°, 85; 1320°, 62; 1460°, 50; 1540°, 37; and 1600° C., 30 kilos. per sq. cm. On extrapolating these figures to 1700° C. (the normal temperature of the arches of steel furnaces), the crushing strength of the bricks would only be 12 kilos. per sq. cm., but as this is about ten times the pressure of the superincumbent brickwork, the stability of the bricks in the arches is assured. This mechanical strength at high temperatures is a special characteristic of silica bricks; it is not possessed by clay or magnesia bricks, though magnesia has a higher melting point than silica. In a silica brick the silica forms a continuous network the pores of which are penetrated by the molten silicates without affecting the strength of the brick. The formation of this network by the recrystallisation of the silica is due to the different solubilities of the various forms of silica, quartz crystallising from the molten magma first as cristobalite and later as tridymite. The quality of silica bricks depends primarily on the development of a satisfactory network by careful control of the proportion of fluxes, the temperature of the bricks when in use, the formation of the network, and its eventual destruction. Several bricks which gave excellent results in use were found to contain 3–5% metallic oxides corresponding to 8–14% sulphates, the ratio of the oxides to sulphates averaging 35 : 100. This ratio may be determined with fair rapidity and is characteristic of satisfactory silica bricks. The temperature at which the bricks should be burned depends on the purpose for which they are to be used. For lining steel furnaces, a burning temperature of 1700° C. is desirable. For the distillation of oil, on the contrary, a much lower burning temperature will suffice and the bricks may contain twice the amount of metallic oxides mentioned above.

The formation of the network is the most delicate part of the manufacture of silica bricks. It requires a prolonged heating at about 1450° C. for several days, the rate of formation being most rapid when the grains of quartz in the brick are extremely minute. A sufficiency of larger grains must be present, however, in order to prevent the formation of the minute fissures which are pr duced when the material is composed wholly of fine grains.

When the bricks in use are heated rapidly to the temperature at which any unconverted quartz grains are inverted, the expansion which accompanies this charge of form breaks the network and lessens the strength of the bricks. Moreover, the pressure of the brickwork in an arch opposes any lateral expansion and produces spalling, which is one of the worst defects of badly-made silica bricks. In a well-burned brick, an expansion also occurs at the moment when larger grains of quartz are inverted to cristobalite, but its effect is less serious, as these grains are able to expand in all directions, and it occurs sufficiently slowly for the network to be reformed at the point where it has been damaged. Nevertheless, this phenomenon notably reduces the strength of the bricks. The results of determinations of the sulphate equivalent of the oxides, true and apparent sp. gr., and the crushing strength at 1600° C., have a crushing strength of at least 10 kilos. per sq. cm. A prolongation of the heating at this temperature reduces the strength of the bricks. The results of determinations of the sulphate equivalent of the oxides, true and apparent sp. gr., and the crushing strength at 1600° C. after sixty re-heatings showed clearly that good silica bricks, after heating for 1 hour at 1600° C., have a crushing strength of at least 10 kilos. per sq. cm. A prolongation of the heating at this temperature reduces the crushing strength of well-fired bricks, but increases that of underburned ones." — H. Le Chatelier and B. Bogitch, *Comptes rend.*, 1917, *165*, 218-224.—*Journal of the Society of Chemical Industry*, September 15, 1917, p. 963. (J. A. W.)

New Alloys to Replace Platinum.—"Alloys of gold and palladium, as the chief constituents, were prepared, and gave results which for many purposes were quite equal to those given by platinum. The name 'rhotanium' has been given to this series of alloys, which contain from 90% to 60% of gold, according to the purposes for which they are required. For certain electrical and other uses the addition of a small proportion of rhodium is essential, but this is not necessary in the case of material for chemical ware. A small amount of silver may also be introduced into alloys which are not intended for chemical purposes. In the preparation of rhotanium alloys great care is required to obviate the affinity of palladium for gases and solids ordinarily met with in manufacturing processes, and also to regulate the heat so as to prevent segregation of the constituents. The slightest want of homogeneity makes the alloy worthless for many purposes, and especially for chemical requirements. Comparative tests with boiling acids, alkali and alkali sulphide solutions, and by fusion with potassium bisulphate showed that, excepting for use with nitric acid, an alloy may be chosen which will give results equal to or better than those given by platinum. The loss by volatilisation in 10 hours at temperatures of 1050° to 1400° C. was lower than for platinum in the case of some of the alloys. At 1400° C. the crystalline structure was clearly shown, but no brittleness was produced. Some of the alloys are practically indistinguishable from platinum in colour, and are equally malleable and ductile. They melt at temperatures up to 1450° C., and have an electrical conductivity and tensile strength equal or superior to those properties of platinum. The sp. gr. varies from 18·5 to about 16·0 (platinum 21·5), and the temperature co-efficient is much lower than that of platinum. These alloys may be welded readily at white heat without the use of a flux, and may be made into any shape while either cold or hot. Rhotanium has been found suitable for contact terminals in automatic-electric devices, and in most other cases where it has been found necessary to use a platinum alloy containing a large proportion of iridium, but it has not given uniformly satisfactory results in magnetos. For dental work it has proved as useful as platinum for most purposes. It cannot be used in chemical work, as an anode in electrolytic analysis, or when exposed to the action of strong nitric acid, but is a satisfactory material for cathodes. It is superior to platinum for jewellery, being harder, stronger, and taking a better finish. It may be "sweated" or otherwise treated as platinum without darkening or oxidising, and the finished articles cannot be distinguished by ordinary means from those of platinum."—F. A. Fahrenwald, *J. Ind. Eng. Chem.*, 1917, *9*, 590-597.—*Journal of the Society of Chemical Industry*, August 15, 1917, p. 882. (J. A. W.)

Possible Adulteration of Nitric Acid.—"Attention is drawn to the possibility of nitric acid being adulterated by the addition of sodium nitrate or other sodium salts, and dilution of the solution to the required sp. gr. with water. Nitric acid of sp. gr. 1·381, when saturated at 15° C. with sodium nitrate, contains 3·24% of the salt, and has a sp. gr. of 1·399. A saturated mixture of sp. gr. 1·380 will contain 4·83% of sodium nitrate and 8·30% of water. In like manner, nitric acid of sq. gr. 1·381 will dissolve 12·62% of sodium sulphate, giving a sp. gr. of 1·416, whilst a saturated mixture of sp. gr. 1·374 will contain 12·62% of sodium sulphate and 15·15% of water. Hence, the determination of the sp. gr. and of the NO_3 content of nitric acid ought always to be accompanied by an evaporation test for dissolved salts." — I. R. Withrow, *J. Ind. Eng. Chem.*, 1917, *9*, 771-776.—*Journal of the Society of Chemical Industry*, Sept. 29, 1917, p. 1005. (J. A. W.)

METALLURGY.

Electric Smelting of Titaniferous Iron Ores.—"A deposit of titaniferous magnetite estimated to contain 1,000,000—5,000,000 tons occurs near St. Charles, Quebec. Electric power may be obtained close by from the Saguenay River, and supplies of charcoal and limestone are also available. The ore contains 50·53, titanium 10·55, sulphur 0·02, and phosphorus 0·03%, and yields a magnetic concentrate assaying iron 56·2 and titanium 8·3%. It is estimated that 1·75 tons concentrate smelted in a Swedish furnace would yield 1 ton of pig iron with 0·4% of titanium, and 0·7 ton of slag containing titanium 34 and silica 14%. The electric power required would approximate 0·55 H.P.-year per ton of metal; the total cost of production would be $17.93 per ton." A. Stansfield, *Canadian Geol Survey, Bull.* 92; *Eng. and Min. J.*, 1917, *103*, 1020.—*Journal of the Society of Chemical Industry*, August 15, 1917, p. 881. (J. A. W.)

Metal Colouring I., "Shakudo"; II., New Kind of "Shakudo," and "Shibuichi."—"Shakudo is an alloy consisting essentially of copper and gold, which is used in Japan for the manufacture of objects of art and is coloured by treatment with aqueous solutions containing copper sulphate and acetate. The author's experiments show that the coloration is due to the production of a layer of cupric oxide, the tint being determined by the thickness of the layer. The colouring solution contains hydrogen ions owing to hydrolysis of the copper salt, and when the alloy is introduced a local electrical circuit is formed between the gold and copper, the latter being dissolved as cupric ion and hydrogen ions being discharged, thus disturbing the equilibrium. In consequence of this, hydrolysis proceeds further, and the process goes on, with progressive increase of the concentration of cupric and hydroxyl ions, until the solubility product of cupric hydroxide is exceeded. The precipitated hydroxide is rapidly converted into the oxide, which is deposited on the surface of the alloy. An analogous coloration can be obtained on alloys containing palladium, platinum and silver, respectively, in place of gold.

In confirmation of these views as to the mechanism of the coloration of shakudo, it is shown that a similar effect is produced by mere contact of copper with platinum, palladium, or gold in the solution used, and that an electric current is produced when a copper electrode is connected by a copper wire with a platinum or palladium electrode immersed in acid or in the salt solution used for colouring shakudo. The colouring of 'shibuichi,' an alloy of 25% of silver and 75% of copper, used for purposes similar to those mentioned for shakudo, is due to an analogous cause."—S. MIYASAWA, Kogyo Kwagaku-Zasshi (*J. Chem. Ind.*, Tokyo), 1917, *20*, 109-134, 365-384.—*Journal of the Society of Chemical Industry*, August 15, 1917, p. 884. (J. A. W.)

IMPURITIES IN ELECTROLYTIC COPPER REFINING.—"The general question of impurities is discussed under five main headings: (1) sources, (2) exits, (3) distribution, (4) recovery of soluble impurities from the electrolyte, (5) recovery of insoluble impurities from the anode slimes. Apart from the pig copper, the chief sources of impurities are fuel, fluxes, and acids, and the exits are outgoing commercial products, slags, and stack gases; the tendency to-day is to check stack losses. The distribution of impurities depends partly upon their chemical characteristics and partly upon the metallurgical practice of the individual plant. Silver, gold, tellurium, and selenium, which do not dissolve in the electrolyte, show a cathode recovery of over 99%. Nickel passes into solution to the extent of nearly 99%, and arsenic forms a light slime, which passes chiefly into solution, the recovery being 97%. Iron and zinc also pass principally into the electrolyte, whilst lead, antimony, bismuth, and sulphur pass chiefly into the slimes. In the purification of the electrolyte, sufficient must be withdrawn daily to control the amounts of the chief impurities, generally nickel and arsenic. The early methods of purification consisted in separating the copper by means of scrap iron, but this was later displaced by the manufacture of commercial copper sulphate. The modern method of purifying the electrolyte is to divert part of it to vats containing insoluble lead anodes, at a rate sufficient to keep the determining impurity, generally nickel or arsenic, at the desired point. From these vats good cathode copper is obtained, then a poor copper which is returned to the anode furnaces, and finally sludge which passes to the smelter. The liquor is then passed into a steam boiling vat and into evaporators, and finally on to sand filters for removing the nickel salts, the liquor being afterwards cooled to separate the sodium salts. The strongly acid filtrate is then again used as electrolyte."—L. ADDICKS, *Met. and Chem. Eng.*, 1917, *16*, 687-692.—*Journal of the Society of Chemical Industry*, September 15, 1917, p. 966. (J. A. W.)

WORLD'S PRODUCTION OF CRUDE PLATINUM.—The following table shows the world's production of crude platinum for the last eight years in troy ounces:—

Countries.	1909	1910	1911	1912	1913	1914	1915	1916
Borneo and Sumatra ...	500	200			200	(a)	(a)	(a)
Canada ...	30	30	30	30	50	30	100	60
Colombia	6,000	10,000	12,000	12,000	15,000	17,500	18,000	25,000
New South Wales and Tasmania ...	440	332	170	778	1,500	1,248	303	232
Russia ...	264,000	275,000	300,000	300,000	250,000	241,200	124,000	63,900
United States	672	390	628	721	483	570	742	750
Total ...	271,642	285,952	313,128	313,529	267,233	260,548	143,145	89,932

(a) No basis for estimate.

Journal of the Society of Chemical Industry, July 16, 1917, p. 719. (J. A. W.)

MISCELLANEOUS.

CHICORY SUBSTITUTE FROM SOUTH AFRICA.—"The inhabitants of certain parts of South Africa, particularly in the Waterberg and Zoutpansberg districts, Transvaal, utilise the dried roots of the 'witgatboom' tree (Capparis albitrunca Burch.) as a substitute for chicory. A sample of the product submitted in November, 1916, to London was stated by a firm of chicory manufacturers to be a very good substitute for chicory, but could not be used as its use would be illegal in the United Kingdom. The price in South Africa was given as 20s. per 100 lb. (Feb., 1917). The tree is said to occur plentifully in the Transvaal districts mentioned, also throughout Namaqualand to Griqualand West."—*Bulletin Imperial Institute*, Vol. XV., No. 1, Jan.-March, 1917, pp. 112–113. (J. A. W).

South African Gum.—"A sample derived from the 'white thorn' Acacia horrida was examined, and yielded a mucilage possessing good adhesive properties, which was found to contain 14·5% moisture, 2% matter insoluble in water, and 2·9% ash. It had an acid number 3·9 (good Soudan gums 1·2—2·4), whilst the relative viscosity of a 10% solution at 22° C. was 8·0 (hard Kordofan gum being 12·0).

'There appears no reason why this gum should not find a market in South Africa for use in confectionery, pharmaceutical preparations, adhesives, etc. If a local market of this kind were established and the collection of the gum organised, it might be feasible to start an export trade to the United Kingdom, as it would then be possible to ensure regular deliveries of the gum.'"—*Bulletin Imperial Institute*, Vol. XV., No. 1, Jan.-March, 1917, pp. 111-112. (J. A. W.)

Fibres from various Sources.—"*Jute from Egypt.*—The sample was grown at Cairo from Indian seed and had been prepared by a special (alkaline) process: it was inferior in colour and lustre to Indian jute of fair quality prepared by retting. Owing to the method of preparation the loss on hydrolysis was abnormally low: the presence of a small amount of alkali, owing to insufficient washing, was detrimental to quality. The sample was valued at £36—£37 per ton, as compared with Calcutta jute at £41.

Sida rhombifolia fibre, known as 'vivane,' was received from Swaziland. The sample was clean, well prepared but somewhat harsh; it was of good strength and about 2 ft. in length. Fibre of this quality but 4 ft. in length would be worth £3 to £4 less than Calcutta jute. A larger sample received later was not well prepared; it was harsh, mostly matted and gummy, and poor in lustre; the cellulose content (70·5%) was low and the hydrolysis losses abnormally high on this account. The fibre was valued at only £17—£18 per ton with Calcutta jute at £28; such a fibre would be saleable for mixing with jute when the price of the latter is high. Better results should be obtainable by improved methods of retting.

Hibiscus cannabinus fibre from Rhodesia.—This fibre had not been well prepared and the retting appeared to be uneven; the strength was irregular and the length varied from 4 ft. to 6 ft. The hydrolysis results were high and the cellulose content low. The sample was inferior in colour, softness, and general appearance to Bimlipatam jute prepared in India from the same plant. The fibre was valued at £27 per ton, as compared with Calcutta jute at £32; the low quality is attributed to inexperience in the retting process. *Hibiscus* fibres of the same species were obtained from Egypt and from Nyassaland. The Egyptian fibre had been prepared by a special treatment and had not been washed free from alkali; it was consequently inferior in appearance and deficient in lustre. Two samples from Nyassaland gave high hydrolysis losses and low cellulose content; one was of moderate quality and the other distinctly inferior.

Nettle fibre from India.—The sample consisted of uneven, very tangled fibre, brown to pale buff in colour, with many green portions. It had apparently been prepared merely by mechanical treatment and contained most of the gum and was coated with bark. The length of staple was mainly about 3 ft. 6 in., composed of extremely fine ultimate fibres 4—5 in. in length. In the crude state the fibre would have little value but might be used in coarse jute goods. The degummed fibre would hardly be a suitable substitute for flax or ramie, being deficient in strength and spinning qualities. The fibre might be obtained sufficiently clean and free from gum and bark by retting to be used in admixture with jute or hemp, but if retting were not practicable in India, it might be saleable in the form of clean bark ribbons prepared by scraping away the outer bark as in the preparation of China grass.

Sisal hemp from Rhodesia.—A sample of sisal hemp grown under experimental conditions was found to be exceptionally well prepared. The length of staple was mainly 2 ft. 6 in. to 3 ft. and if this had been slightly greater the sample would have ranked among the first-class materials of this species.

Furcræa fibre from Southern Rhodesia.—This fibre was fairly clean and well prepared but inferior to previous samples from the same source; the cellulose content (72%) was lower and loss on acid purification higher, indicating insufficient washing. The length varied from 3 ft. to 8 ft., mostly 5 ft. to 5 ft. 6 in. Better removal of the pith by brushing and sorting of the fibres into more uniform lengths would increase the value. Another sample of *Furcræa gigantea* fibre from South Africa was insufficiently cleaned but of good length and strength; it was estimated at a value of £20—£21 (Oct., 1915) but would be readily saleable at a much higher price if properly prepared.

Asclepias fruticosa fibre from South Africa.—This is locally known as 'melkbosch' and is widely distributed. Two samples were examined which, however, were not well prepared and contained a good deal of bark. The staple was not sufficiently long (most 20—22 in.) to compare favourably with sisal. The fibre was harsh and of poor lustre, but exceptionally rich in cellulose (82%) and might possibly be found useful as a basis for nitrated explosives. In comparison with sisal hemp at £50 the samples were valued at £32—£38 per ton.

Kapok from the Sudan and Togoland.—The Sudanese sample was not quite free from pod residues, but after cleaning it yielded a floss of excellent quality equal in resiliency to Java kapok. In Togoland a trade in kapok has been developed by the Germans, 9 tons having been exported in 1913. The quality of the sample bale received may be regarded as normal, and it is considered that encouragement should be given to the development of the industry.

Asclepias fruticosa floss from South Africa.—This floss is somewhat brittle and inferior in resiliency to kapok, and corresponds to the material known in the trade as 'Akund.' Its value in this country is considerably lower than that of kapok and it is not so suitable for the manufacture of life saving appliances.

Seed hairs of Ipomœa albivenia from South

Urena.—This material is known locally as Kafir or Natal cotton and resembles harsh unginned cotton of dark cream colour. The fibres are triangular in section, untwisted, and much thinner in the walls than cotton fibre, and only about 0·3 in. long. The raw fibre is much more absorbent and spinning qualities of the cotton fibre. The material contains only 77·3 % of cellulose and does not appear to be a very promising commercial article, though it might fetch a low price as a stuffing material considerably inferior to kapok."—*Bull. Imp. Inst.*, 1917, *15*, 7-23—*Journal of the Society of Chemical Industry*, Sept. 27, 1917, p. 1003. (J. A. W.)

Utilization of Phosphate Rock.* "These inventors (Newberry and Fishburne) have patented a number of processes for the production of citrate soluble phosphoric acid from natural phosphates, but their most recent scheme consists in heating to a sintering temperature in a rotary kiln a mixture of phosphate rock, sodium carbonate and limestone. The following procedure, it is claimed, gives excellent results:

1. Grind the phosphate rock to fine powder.
2. Add an amount of sodium carbonate approximately equal to one-half of the phosphoric acid in the charge of rock.
3. Add a quantity of limestone equal approximately to one and one-half times the silica present in the charge of rock.
4. Calcine the mixture at nearly white heat to the point of semi fusion.

The charge is calcined in a rotary cylinder lined with some basic refractory material."—G. A. Roush—*The Mineral Industry*, 1916, Vol. XXV., p. 584. (W. A. C.)

Abstracts of Patent Applications.

264.16. Gogu Constantinesco (1), Walter Haddon (2). Improvements in power-driven reciprocating implements and means for driving the same. 27.10.16.

This application refers to a reciprocating implement, such as a hammer or hammer drill operated by alternating liquid currents in connection with the wave transmission system which has already been patented by the applicants. Other claims are for apparatus in connection with the main application.

281.16. John Glynn. Improvements relating to the loading and unloading of trucks and other similar railway vehicles. 9.11.16.

This application refers to an arrangement of a collapsible box for use in loading or unloading loose material to or from railway and other trucks.

11.17. William John McQueen. Improvements in the linings of tube mills. 15.1.17.

This application relates to improvements in tube mill liners, and consists in providing sectional lining parts laid around the inner side of the shell of the mill with holes suitably formed to support T shaped members. These latter members project radially into the mill and serve to retain portion of the grinding charge and prevent wear, as well as to connect and interlock the sectional bars.

21.17. Jacobus Louw Cruywagen. Improvements in means for laying the floating dust out of the atmosphere in mines. 23.1.17.

This application relates to dust allaying, by means of water placed in a trough or vessel which is sprayed by means of a jet or jets of compressed air which blows the water into a fine mist. Other claims refer to apparatus to accomplish the object aimed at in the main claim.

360.17. Charles Owen Griffith. An improved process for the production of metallic sulphides. 22.6.17.

This application relates to the production of metallic sulphides by an electrical process, and for this purpose employs a cell in which the anode and cathode are formed of the same metal which forms the base of the sulphide desired. The electrolyte used is a solution of ammonium or other suitable sulphide. Upon passing current through the cell sulphuretted hydrogen is given off at the cathode and metallic sulphide is deposited in the cell.

566.17. Karl Byron Moore (1), Herbert Richard Edmands (2). Process of and apparatus for precipitating and recovering gold and silver from their cyanide solutions. [illegible].9.17.

This application relates to a combination process and apparatus for precipitating gold and silver from cyanide solutions. The former consists of washing and grinding fresh charcoal and feeding the charcoal pulp to especially designed vacuum extractors, operated in stages, with the object of obtaining maximum precipitation with minimum consumption of charcoal. Special means are taken in the subsequent recovery stages, which means, the applicant claims, represent improvements on present known methods.

The apparatus claims consist of a combination of means for grinder charcoal, means for feeding the charcoal to the vacuum extractor units, storage vats, and means for feeding the solution in stages to the various extraction and clean-up units employed.

579.17. Hermann Belger. Improvements in or connected with the treatment of dust in mines, tunnels and other places. 2.10.17.

This application refers to a solution for allaying dust in mines, consisting of calcium chloride or magnesium chloride, with glue or equivalent substance dissolved in water.

Changes of Address.

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

O'Reilly, R. E., *l/o* Pilgrims Rest; P.O. Luipaardsvlei
Phillips, J. C., *l/o* Benoni; P.O. Box 28, Brakpan
Pursglove, H. W., *l/o* Springs; Uitkyk Collieries, Ltd., Uitkyk, Transvaal.
Richardson, W. P., *l/o* Louw's Creek; Maid of De Kaap, Consort P.O., near Barberton
Rogers, Dr. A. W., *l/o* Pretoria; c/o Mining Commissioner, Heidelberg, Transvaal
Wyly, A. J., *l/o* Lebong Sandai; Lebong Donok, Benkoelen, Sumatra, Dutch East Indies

---

* See this *Journal*, Vol. XVIII, Nov. 1917, p. 14

APR 1 5 1920
UNIVERSITY OF T

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII JANUARY 1918. No. 7.

For Discussion at the February Monthly Meeting.

THE MANUFACTURE OF CRUDE SODIUM MANGANATE FOR USE ON THE MINES.

By F. WARTENWEILER (Member of Council).

In view of the shortage of easily soluble oxidizers for use in the reduction works, permission was granted by Rand Mines, Limited, to demonstrate on a practical scale the experimental results obtained at the Metallurgical Laboratory in producing this chemical for use in substitution of the nearly pure potassium permanganate formerly used and available at a reasonable cost. The work was carried on in a ton-hearth brick muffle type calcining furnace, ordinarily used for calcining acid treated zinc-gold precipitate on these fields. In general, the working tests confirmed the laboratory research and established that sodium manganate of practical value can be produced. No particular difficulty is encountered in manufacture if the general principles are followed. Our experience, conclusions and results are given in the following notes:—

Chemicals Used.—Ferruginous manganese dioxide ore (pyrolusite) from Pretoria district, containing 40% manganese; caustic soda, commercial 98–98% purity; potassium nitrate, commercial.

Combinations of Chemicals Used.—It is necessary to use a large excess over the theoretical requirement of caustic soda, or 110 units of caustic soda for every 100 units of 40% manganese ore to get a reaction. With anything less, no manganate is formed. With a larger excess of caustic soda, conversion is improved.

The combinations found most effective are:—

(a) 1 part by weight of 40% Mn ore to 1·44 parts of caustic soda.

(b) 1 part by weight of 40% Mn ore to 1·10 parts caustic soda and 0·4 parts nitre.

With (a) combination—practical results were obtained in two hours of heating at a temperature, ranging from 650° C. to 750° C. as determined with Seger pyrometric cones. The product analysed 18·2% soda manganate on an average. With only one hour of the same heat, an average of 17·2% was produced.

By heating at a lower temperature and over a longer period a richer product (28%) was made. The method in this case was: Heat the furnace to a temperature of 450° C. prior to adding the charge, add the charge, and gradually raise the heat to about 560° C., maintaining this heat for eight hours, then allow the furnace to cool for four hours, when the charge may be withdrawn. This method is now used for producing our requirement of manganate.

With the (b) combination—practical results were obtained by heating from two to three hours at a low red heat of 650° C. to 750° C., producing a product averaging 21·9% soda manganate. Here again, leaving the charge in the furnace over a longer time, and gradually cooling resulted in a higher conversion, to 27% soda manganate.

Practical Considerations.—The manganese ore used in the manufacturing is ground in a ball mill to the following grading:—

	Per cent.
Retained on 60 mesh	5·7
Pass 60 and retained on 90 mesh...	14·5
Pass 90 and retained on 200 mesh	18·2
Passed 200	61·6

The laboratory tests were carried out with ore ground to 86·6% −90 mesh, with practically no +60 mesh. No improvement in conversion resulted from the use of the more finely comminuted ore.

The chemicals are well mixed before feeding to the furnace in charges up to 500 lb. for each one of the four hearths. This amount forms a mass over the hearth about 6 in. deep. No stirring or rabbling is necessary. By the end of the heat, the product has agglomerated and has to be prised loose, out of the furnace in a more or less lumpy condition which necessitates breaking before dissolving. The lumps, however, if exposed to the air by the exigencies of use, retain their manganate strength longer than the finely crushed product does.

As the sodium manganate produced decomposes gradually upon exposure to air, it is packed in sealed packages and should be so stored. The loss of weight during the reaction in the furnace has been found to average 12·5%, *i.e.*, for every 100 lb. for charge used 87·5 lb. of crude soda manganate is produced.

Chemistry.—The reactions in producing sodium manganate without and with an extra oxidizer like nitre, are generally given thus:—

Without Nitre:

$$3MnO_2 + 2NaOH = Na_2MnO_4 + Mn_2O_3 + H_2O.$$

With Nitre:

$$2KNO_3 + 2MnO_2 + 4NaOH = 2Na_2MnO_4 + 2KNO_2 + 2H_2O.$$

A large amount of uncombined caustic soda is present in the crude manganate product as is borne out by its causticity. As caustic soda decomposes by heat only at the high temperature of 1,250° C., according to Molinari, there can be but little loss from the low temperatures employed. When exposed to the atmosphere, the manganate is slowly and gradually converted into sodium permanganate, manganous carbonate and manganese dioxide, most likely by the moisture and the carbon dioxide present in the air. This decomposition and reversion is shown by an experiment made on coarse lumps and manganate finely ground.

Manganate product exposed	Coarse lumps	Ground.
Original Na_2MnO_4 content	21·9	21·9
After 50 hours exposure.		
Na_2MnO_4 content	22·7	15·3
After 218 hours exposure.		
Na_2MnO_4 content ...	20·2	9·7
After 458 hours exposure.		
Na_2MnO_4 content ...	17·2	8·6
After 770 hours exposure.		
Na_2MnO_4 content ...	15·6	—

The analytical method used in the quantitative determination of the sodium manganate is based on the water dilution and sulphuric acid conversion of the manganate to permanganate.

$$3Na_2MnO_4 + 2H_2O = Na_2Mn_2O_8 + MnO_2 + 4NaHO.$$

$$Na_2Mn_2O_8 + 5H_2C_2O_4 + 3H_2SO_4 = Na_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O.$$

The solution of permanganate formed is titrated with oxalic acid, which has a value of:—

$$1 \text{ cc. } N/10\ H_2C_2O_4 = 0·00495 \text{ gm. } Na_2MnO_4.$$

No attempts have been made to produce a refined product, as the crude managanate can be substituted on the mines for all services for which formerly the refined potassium permanganate was used.

The soda manganate is more soluble than bleaching powder, and is easier to handle and control. When once dissolved and converted to permanganate by dilution with water, it is comparatively stable.

Correspondence and Contributions.

MERCURY

As with other mining supplies, mercury has become much scarcer and dearer with the progress of the war and the local price is now £27 per flask of 75 lb., as against a pre-war price of £8 per flask. Besides other causes, this is apparently due to increased consumption by the Allies as fulminate of mercury for munitions, and to the output from Austria not being available, although production in California and elsewhere has been stimulated by high prices.

The U.S.A. production of mercury for 1916 was nearly 30,000 flasks of 75 lb. each, or rather more than the Tuscan mines in Italy. The Almadin mines in Spain produced nearly 60,000 flasks.

The consumption of mercury on the Rand is practically all due to the amalgamation of gold, though some time ago the Modderfontein Dynamite Factory successfully manufactured for use as a disinfectant 100 lb. of corrosive sublimate (mercuric chloride) from a flask of mercury. On the mines mercury is, of course, in continual circulation and re-use through the plates, amalgam, and retorts with a constant wastage, which is largely in the form of minute particles abraded from the amalgamated plates by the particles of ore in the pulp passing over them, and which naturally increases with the coarseness and velocity of the pulp. On one group of mines without stamp mill plates, the total consumption of mercury in oz. (Troy) per ton of ore milled is on an average equal to 7% of the amalgamated plate area (in sq. ft.) in use per ton of ore milled in 24 working hours. In consequence of fluctuations in the amount of mercury retained on plates and in tube-mills, launders, pump pits, etc., it is necessary to take periods of several months to obtain correct comparative figures regarding average actual consumptions of mercury.

Very finely divided or "floured" mercury in the pulp leaving the crushing plant is deposited in the collected sand and slime, and subsequently largely dissolved by the cyanide solution along with the gold, and if under certain conditions similarly precipitated in the zinc boxes. Possibly a portion of the mercury after dissolution is precipitated in the charge, like a dissolved lead salt, as sulphide by soluble sulphides derived from the ore, and hence finally discharged with the sand and slime residues. Any loss of mercury from this source might possibly be decreased by increased use of lead salt in the working solutions.

A little mercury is lost mechanically in handling as amalgam, or during steaming and retorting as vapour, and some is recovered by the Witwatersrand Co-operative Smelter in the black sand by-product sold to them. The actual consumption of mercury in a reduction works naturally increases with an increased area of amalgamated plates in use. In a modern plant without plates in the stamp mill, practically all the gold recovered by amalgamation on the tube-mill plates has previously been classified out of the pulp with the coarser particles by the tube-mill and safety cones, and hence efficient classification is the primary requisite for ensuring a satisfactory amalgamation recovery of the gold contents of the ore, and for reducing to a minimum the loss of mercury in the tube-mill return pulp. Practice regarding the tube-mill plate area considered necessary varies considerably on different mines from three 4 ft. 9 in. by 12 ft. plates per tube-mill to six plates and upwards per tube-mill. The capital represented by the plates, copper and amalgam, and the labour of dressing, of course increase with the number of plates. In consequence of different practice, the mercury consumption per ton of ore milled varies greatly from an average of 0·04 oz. (Troy) per ton of ore milled on certain mines to an average of about 0·12 oz. (Troy) per ton of ore on the majority of Rand mining companies.

In view of the present pooling system for mine supplies, all mines have a common interest in the saving of mercury, and although blankets could be employed in place of plates if absolutely necessary, yet this course would involve additional labour and expense to be avoided if possible. It may prove practicable to pass the gases from the calcination of zinc gold slime for the recovery of mercury through condensing flues and chambers or filters.* One form of condenser consists of the flue-pipe led through a tank of water to cool it. A good many years ago the writer recovered a flask and a half of mercury by retorting the acid-treated zinc-gold slime from Sheba pan tailings.† In general, the problem of mercury economy, and recovery in part if practicable, is worthy of serious consideration by members, and any data and results of trials for its solution would be of value.

W. A. CALDECOTT.

30th January, 1918.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

SOME FACTORS INFLUENCING THE SOLUBILITY OF PHOSPHORIC OXIDE IN MIXED FERTILISERS CONTAINING SUPERPHOSPHATES.—"*Conclusions.*—Superphosphate can remain mixed for as long as three weeks with either sulphate of ammonia or sulphate of potash or kainit without an appreciable loss of water-soluble phosphoric oxide, and if mixed with sulphate of ammonia there is a possibility of an actual increase of water-soluble phosphoric oxide in a period of three weeks.

If immediate reversion of water-soluble phosphoric oxide is to be avoided Government guano should on no account be mixed with superphosphate, for in a mixture of equal parts of the two there is, even after three hours, a total loss of nearly 7% of the water-soluble phosphoric oxide.

In the case of bone-meal there is a loss of 2% of water-soluble phosphoric oxide in three hours, but if left for a period of fourteen days there is considerable loss, amounting to over 14½%.

It is quite evident that the two samples of kainit as used by Prof. Gray (of Canterbury, N.Z.) and myself varied considerably, judging from the loss of water-soluble phosphoric oxide; the substance used by the former caused a loss of nearly 7% in eighteen days, whereas in my case there was a slight increase of water-soluble phosphoric oxide. These remarks apply also to the two bone products used; in the former case there was a loss of only 2¾% in eighteen days, as against 11½% in fourteen days with the substance used by me."—EDMUND V. FLACK, *So. Afr. Jl. of Science*, XIII., No. 5.—*Chemical News*, June 22, 1917, p. 291. (J. W.)

---

* See Egleston's "Metallurgy of Silver, Gold and Mercury in the United States." Vol II.

† See this *Journal*, 21st August, 1894, Vol. I., p. 23.

PHOSPHOR-TIN, AND A VOLUMETRIC METHOD FOR ITS ANALYSIS.—"In principle the method involves dissolving the alloy in HCl to form $SnCl_2$ and PH_3. The first is titrated directly with $KMnO_4$ solution; the second is oxidized in absorption flasks and precipitated with molybdate solution. An apparatus for the method is described. Check analysis carried out by other methods proved the proposed method to be highly accurate."—RICHARD E. LEE, W. H. FEGELY and FRANK H. REICHEL, *J. Ind. Eng. Chem.*, *9*, 663-8 (1917).—*Chemical Abstracts*, August 20, 1917, pp 2309-10. (J G.)

A RAPID METHOD FOR ESTIMATING NICKEL AND COBALT IN ORES AND ALLOYS.—"The method is based on the fact that KI precipitates Ni and Co in ammoniacal solution as $(Ni(NH_3)_6)I_2$ and $(Co(NH_3)_6)I_2$. Sufficient KI must be added over and above the quantity required for precipitation (0·6 gm. KI per 0·1 gm. Ni+Co) to yield a solution containing 4%, of the precipitant. The KI is added in the form of a cold, saturated solution immediately after the NH_3. The NH_3 (sp. gr. 0·88) should be 2/3 to 1/5 of the total, which should not greatly exceed 80 cc. With quantities of Ni or Co exceeding a few milligrams the precipitation is almost instantaneous. Precipitation of amounts less than 2 mgm. can be hastened by adding a little strong Na_2SO_4 solution. As water decomposes the precipitate, it must be washed with cold solution containing 800 cc. strong NH_3 and 40 gm. KI per litre. For the separation and estimation of Ni and Co the washed precipitate is rinsed back with water into the precipitate flask without removing the paper from the funnel. The filter is washed with dilute HCl and a small quantity of H_2SO_4 to bleach the filter coloured by I, the washings being allowed to run into the flask containing the precipitate. The latter is dissolved in a small excess of HCl, more H_2SO_4 being added if necessary. The solution is then filtered through the same filter into a 300 cc. beaker. Co is then precipitated as cobalt ammonium phosphate, which may be titrated according to the authors' alkalimetric method (*C.A.* *10*, 1972). The ammoniacal filtrate containing Ni is titrated with cyanide, no indicator being required as the liquor already contains iodide. The small amount of sulphite if not previously destroyed by boiling has not been found to interfere with the Ni titration. As the property of forming complex iodides insoluble in water under the conditions described is common to several bivalent metals, the behaviour of these elements when present with Ni and Co is discussed. It is shown that the method is applicable to ores containing Fe, Cu, Ca, Mg, As and S, if proper precautions are taken."—W. R. SCHOELLER and A. P. POWELL, *Analyst*, *42*, 189-99 (1917).—*Chemical Abstracts*, Sept. 10, 1917, pp. 2137-8. (J. G.)

INFLUENCE OF BASE METALS IN GOLD BULLION ASSAYING.—"An experimental study reported in detail from which the author concludes: 'In small amounts, Zn alone has no effect upon the cupel Au. In large amounts the Zn-Au-Ag alloy is formed, comes to the surface and carries Au to the cupel. A tendency to do this occurs when small amounts of Zn are cupelled with large amounts of Pb. In all the comparative tests Cd showed a distinct protection of the Au, even when Zn was also present. The presence of Cu *per se* directly increases the absorption of Au, but its effect is intensified by the higher temperature and larger amount of Pb required. The effect of Pb varies greatly with the surrounding conditions. The presence of Ag is a good protection to the Au, but may be over-balanced by other conditions.' The author appends a list of references on this subject."—F. P. DEWEY, *Bull. Am. Inst. Mining Eng.*, *1917*, 1015-22; cf. *C.A.*, *5*, 443; *6*, 3247; *7*, 1156.—*Chemical Abstracts*, Sept. 20, 1917, p. 2568. (J. G.)

THE CHEMISTRY OF CARAMEL.—"When sucrose is heated at 170°—180° C., the loss of weight of 12% which takes place does not consist merely of water; even at 168° C. other products, including furfural, pungent vapours, and carbon dioxide, are evolved. Nevertheless, by heating sucrose at 170°-180° C. until the loss of weight is 12%, practically pure caramelan, free from sucrose and higher caramel products, is obtained; the treatment of 300 gm. of sugar requires about four hours. When perfectly dry, caramelan melts at 136° C., but if at all moist it begins to soften at 100° C. It is fairly soluble in 84% alcohol, pyridine, methyl alcohol, or hot glacial acetic acid. It reduces silver nitrate and Fehling's solution and gives red precipitates with hydrochloric acid and resorcinol or phloroglucinol. It may be precipitated from aqueous solution in a flocculent state by alcohol if acetic acid be present. Its composition corresponds to the formula $C_{12}H_{18}O_9$ or $C_{24}H_{36}O_{18}$, its reactions rather indicating the latter. It behaves as a tetrahydric alcohol, yielding a tetra-acetate (m.pt. 107° C.), a tetrabenzoate (m.pt. 105°.) and an explosive tetranitrate. Caramelan forms compounds with phenylhydrazine and semicarbazide which appear to indicate the presence of one carbonyl group in each C_{24} unit, but in all cases these are formed with extensive dehydration, which, being variable according to the conditions, makes the evidence somewhat inconclusive. Concentrated non-oxidising acids, *e.g.*, 40% hydrochloric acid, convert caramelan into caramelin, $C_{24}H_{26}O_{13}$; and therefore have a dehydrating action: caramelin is infusible and insoluble in alkali hydroxides. Dilute acids hydrolyse and dehydrate it, producing dextrose, methylfurfural, and humic acid. The humic acid forms chloro and nitro compounds. Dilute nitric acid has an oxidising, dehydrating, and nitrating action. On oxidation, caramelan tends to yield complex substances and in nearly all cases one carbon atom is removed per C_{24} unit. Among simpler products acetaldehyde has been recognised. Caramelan appears to mark the first step in anhydride formation and condensation which leads from simple sugars to such complex substances as cellulose, humus, and caramelin."—M. CUNNINGHAM and C. DORÉE, *Chem. Soc. Trans.*, 1917, *111*, 589-608.—*Journal of the Society of Chemical Industry*, September 15, 1917, p. 973. (J. A. W.)

Distribution and Uses of Titanium Ores.—"The more important titanium minerals (rutile and ilmenite) are briefly described, and an account is given of their occurrence and distribution throughout the world. Titanium is used chiefly in the purification of iron and steel, for which purpose the carbide or a ferro-alloy is generally employed, the high melting point (1850° C.) and low specific gravity (5·17) of titanium precluding the use of the pure metal. The carbide is prepared by reducing a mixture of the ore and carbon in the electric furnace, the product consisting of microscopic particles of titanium carbide held in a matrix similar to grey cast iron; such material, containing 15—20% Ti and known as 'ferro carbon-titanium,' is the principal form in which titanium is at present employed for steel purification in the United States. Ferro-titanium, containing 10—75% Ti and only 0·12—0·75% C., is produced in quantity by reduction with molten aluminium in the electric furnace; but alloys of German origin are usually obtained by the ordinary alumino-thermic process. The injurious effects of dissolved nitrogen upon steel are counteracted by titanium which, at 800° C., combines with nitrogen to form titanium nitrides; titanium also prevents segregation of the sulphur, phosphorus, and carbon and has the effect of concentrating the blowholes in the pipe cavity. In the case of ferro-alloys the best results are obtained with ferro-titanium containing 10—15% Ti, and an alloy of this composition is now specified in American (U.S.) practice. The alloy is added as the steel is run into the ladle (*i.e.*, after recarburisation and the addition of the necessary ferro-manganese and ferro-silicon), 0·5% of the weight of the molten charge being usually sufficient. Although chiefly employed for treating rail steel, the use of titanium for other steels is steadily increasing. The quantity of titanium-treated steel rail produced in the United States has decreased considerably during recent years, owing to the substitution of open-hearth for the Bessemer steel formerly employed; titanium appears to be generally less beneficial to the former than to the latter. Alloys of titanium and silicon containing 5—70% Ti and 20—75% Si are also used in the iron and steel industry, while cupro-titanium containing 5—12% Ti is employed for degasifying copper and its alloys. To a limited extent titanium compounds are employed in various non-metallurgical industries. Thus, the carbide is used as a constituent of electrodes for arc lighting; the oxalate and various double oxalates are employed as mordants and for dyeing leather; while titanous chloride and sulphate find uses in the textile industry by reason of their powerful acid-reducing properties."—*Bull. Imp. Inst.*, 1917, *15*, 82-98.—*Journal of the Society of Chemical Industry*, Sept. 29, 1917, p. 1012. (J. A. W.)

METALLURGY.

Cyaniding Flotation Concentrate. — "*Introduction.*—Any analysis of the problem of cyaniding flotation concentrate that will help to bring about an economy in the recovery of silver must interest all metallurgists. The present price of silver is high owing to the demand created by war conditions. An increase in the amount now produced will not materially affect the price, but if the cost of production can be lowered the net returns will be higher. A prime factor is a lower cost of freight to the smelters. The distance of a concentrating plant from the smelter, then, is the main proposition. If situated a few miles away it is possible to have the flotation-concentrate treated and obtain reasonable returns. On the other hand, concentrators a hundred miles or more distant must meet such a high freight charge that the net profit becomes smaller. Therefore, to overcome this, the flotation concentrate must be cyanided on the property. As a result of the success attained by flotation in the past four years the cyaniding of the concentrate is at present a subject of intense interest to the metallurgical world.

The cyaniding of flotation concentrate is difficult, owing to the fact that two-thirds of the oil added to the ore usually appears in the concentrate. Finely divided metallic gold in the form of flotation concentrate has been cyanided in several cases[*] without much difficulty while the cyaniding of flotation concentrate containing silver as argentite (Ag_2S) or tetrahedrite ($4Cu_2S.Sb_2S_3$ approximately) has been unsuccessful. Certain minerals are difficult to cyanide in any case, and the oil as retained by the sulphides tends to increase the difficulty. Some metallurgists claim that oil has no effect on the cyaniding flotation concentrate. J. E. Clennell[†] says: 'Starting with a 0·204% KCN solution, and using various oils, my lowest percentage of KCN remaining after agitation was 0·108%. This plainly shows less than a 0·3% consumption of KCN, and also that the oil has no deleterious effect.' Hugh Rose[‡] says: 'The raw flotation-concentrate cyanides with no more difficulty than a gravity-concentrate. The cyanide consumption maintains more or less the same ratio as in the crude ore, namely, 4 gm. of NaCN per gramme of silver. In this test an extraction (meaning 'recovery') of 98% of the gold and silver was obtainable.' The ore that Rose used for this test was notably free from base metals and the silver was in the form of argentite (Ag_2S).

In comparison with this, E. A. Herson says:[**] 'Were it not for the trouble of the oil, the treatment of ore by a combined process of flotation and cyaniding would promise great economy. Cyanide treatment in many cases would be a direct process for recovering the valuable metal of the concentrate without the costs involved in shipment and in smelting. A low extraction is, however, the result.'

The hindrance to high extraction is apparently due to the physical action of the oil, which forms a film-sack or coating around each metallic particle. This coating is thin, but nevertheless may prevent the access of the cyanide solution. It is evident that an oil must be chosen, not alone for its flotative action, but also for the influence it may have upon the extraction by cyanide.

As the cyanide solutions must be used cyclically, serious difficulties are apt to occur. This is ably expressed by P. A. Avery,[††] who says: 'Especially is this true in the precipitating end of the plant. It seems that a combination of oil, alkali, cyanide solution, and zinc-dust bring about the precipitation of a gelatinous compound that clogs the zinc-press cloths, causing pressure to rise beyond dangerous limits. This case is cited to show what might be expected, if certain flotation-oils are not removed before cyaniding. Not only does oil affect the cyaniding of the flotation concentrate but it also affects the zinc-box precipitation. The same reaction would take place in a zinc-box, for zinc is zinc whether it be thread or dust. A nasty oily precipitate might finally accumulate causing a decrease of the inflow and a drop in the precipitative efficiency of the zinc.'

---

[*] *M. & S. P.*, Nov. 29, 1915.

[†] *M. & S. P.*, May 13, 1916.

[‡] *Trans. A.I.M.E.*, Vol. CXVI.

[**] *Met & Chem Eng*, Vol. XIV., p. 675.

[††] *M. & S. P.*, Vol. CXII., p 661.

In the present investigation a series of experiments was made to determine first, the effect of the presence of oil in cyaniding, upon an ore otherwise amenable to cyanide treatment; second, the effect of the presence of oil on the cyaniding of the sulphides, that is, the the flotation concentrate; and third, the possibilities of removing the oil.

Effect of Oil.—For investigation of the first point a silicious ore, assaying 20 oz. silver in the form of silver chloride was obtained and reduced to 200-mesh. To the pulp was added water and oil, thoroughly mixing in a Janney testing-machine. Potassium cyanide and calcium oxide were then added to the solution, which was agitated for 16 hours in inverted glass chimneys fitted for air-agitation of the pachuca type. A blank test without oil was run at the same time to obtain a comparative extraction. The oils used in this test and in those that followed were, crude pine-oil, pine-tar creosote, wood-creosote, coal-tar creosote, and special resin-oil. Three separate groups of tests were conducted in which varying percentages of oil were used. The results of the effect of oil upon an ore amenable to cyaniding show that oil has no noticeable effect upon an ore when no sulphides are present.

In the following table constant factors were: weight of pulp, 100 gm.; 500 cc. water; 0·5 KCN; 1% CaO; 16 hours agitation; through 200 mesh:

TABLE I.

	Oil		Silver		
Trial No.	Kind	%	Head., oz.	Tail. oz.	Extraction %
1.	None	—	20·0	3·3	83·6
2.	Crude pine-oil	0·27	,,	3·4	83·0
3.	Pine-tar creosote ..	,,	,,	3·5	82·4
4.	Wood-creosote ..	,,	,,	3·8	80·5
5.	Coal-tar creosote ..	,,	,,	3·9	80·1
6.	Crude pine-oil ..	0·67	,,	2·9	85·2
7.	Pine-tar creosote	,,	,,	3·3	83·6
8.	Wood-creosote	,,	,,	3·2	84·4
9.	Coal-tar creosote	,,	,,	3·1	84·6
10.	Special resin-oil	,,	,,	3·1	84·6
11	Crude pine oil	2·70	,,	5·6	71·4
12.	Pine-tar creosote	,,	,,	3·4	83·0
13.	Wood creosote	,,	,,	4·5	77·5
14.	Coal-tar creosote	,,	,,	3·1	84·6
15.	Special resin-oil	,,	,,	3·5	82·4

Effect of Oil in Presence of Sulphides.—To note the effect of oil upon sulphides it was desirable first, to cyanide raw concentrate with and without oil, and then to cyanide the flotation concentrate, after which a comparison could be made. The pulp used was from a lead-zinc tetrahedrite ore containing silver. This tetrahedrite has in the past yielded poor recovery in cyaniding. Therefore low results would naturally be expected. Ordinary table and flotation concentrate were obtained as usual. Oil was added, in all cases save one, on the table concentrate, after which the pulps with oil and those without were cyanided for 18 hours in the lamp chimney cells.

The results of these tests show that the presence of oil makes an average difference of 20% in extraction between raw concentrate with and without oil, and 15% difference between the raw concentrate without oil and the flotation concentrate. It is noticeable that the heavy oils give a lower extraction than the light oils. This would be expected from their adhesive qualities and therefore such oils should be avoided if flotation is to be used prior to cyaniding.

In the following table the constant factors were: weight of pulp, 50 gm.; water, 250 cc.; KCN, 0·5%; CaO, 1%; agitation, 18 hours; and oil, 1%.

Removal of the Oil.—When oil is present in small quantities in some materials it can be saponified and washed away from the substance in the form of soap. Furthermore, when the amount of oil is appreciable it can be removed by simple oil-solvents. Roasting expels or destroys the oil, but when silver is present the roasting tends to form an insoluble silver compound. A chloridizing roast is not open to this objection. Clennell and Butters‡ refer to experiments in which roasting was tried. The ore that Clennell was investigating contained gold and silver, but the silver was not considered because of the smallness of the quantity. Clennell says: 'As results obtained by direct cyaniding of flotation concentrate did not prove encouraging we turned our attention to roasting the concentrate previous to cyaniding. Three tests were carried out with the percentages noted below:

TABLE II.

	Oil		Silver		
Trial No.	Kind	Mesh	Head., oz.	Tail., oz.	Extraction %
	Table concentrate				
1.	None . .	100	40·3	18·0	55·0
2.	Crude pine-oil	..	..	21·3	46·6
3.	Pine-tar creosote	..	..	21·9	45·2
4.	Wood-creosote	..	,,	26·8	33·6
5.	Coal tar creosote	..	..	30·3	24·4
	Flotation concentrate				
6.	Crude pine oil	150	68·8	36·4	46·2
7.	Crude pine oil	..	..	38·3	44·2
8.	Crude pine oil	..	,,	38·3	44·2
9.	Crude pine-oil	,,	..	42·0	40·1
10.	Crude pine-oil	..	,,	40·3	42·6

(1) Oxidized roast, water-wash and cyanided . . 97·0 5·0
(2) *Oxidized roast, acid-wash and cyanided 98·8 11·1
(3) Cyanide flotation roast, acid wash and re-cyanide . 64·9 10·9

The most favourable results were found when roasting at a low temperature; under these conditions a maximum amount of copper was extracted by washing with water, and the highest extraction of gold with a minimum consumption of cyanide.

From the last statement it is seen that gold can be recovered easily by cyaniding after the pulp has been roasted at a low temperature. As said before, the silver in an ore can also be recovered by cyaniding after the flotation concentrate has been given a chloridizing roast at a low temperature.

Solvents for Oil.—The following oil solvents have been tried. Hot water, alcohol, ether, alkali, soap, benzine, gasoline, carbon, bisulphide, carbon tetra-chloride, and acetone were used to determine the solvent action on various oils. Into sets of glass beakers small pieces of clean 'steel' galena were placed; oils of different quality were then added to each set of beakers, which were allowed to remain stationary for 15 minutes, that is, about the same length of time that the ordinary particle of sulphide in flotation remains in contact with the oil. Solvents were then added in a similar manner and the results obtained are given in Table III.

---

‡ *M. & S. P.*, Nov. 20, 1917.
* Concentrate.

Cyaniding Flotation Concentrate with Oil Removed.—Alcohol and gasoline gave the best results in dissolving the oil and were therefore used with the flotation concentrate in the next series of tests. The concentrate was visibly cleaner after washing than that which had not been washed. This material was then weighed and cyanided as before. The results show a similarity in the recovery, namely, 60%, with both alcohol and gasoline. The increase of 5% over the result by cyaniding table concentrate in this case is a result of finer grinding, the pulp being ground to pass 150-mesh.

TABLE III.

Solvent	Solvent effect with different oils			
	Crude pine-oil	Pine-tar creosote	Wool creosote	Coal-tar creosote
Hot water	None	None	None	None
Alcohol	Complete	Complete	Complete	Complete
Ether	Partly soluble	Partly soluble	Partly soluble	Partly soluble
NaOH (15%)	Incomplete	None	None	Incomplete
Gasoline	Complete	Complete	Complete	Complete
Acetone	Partly soluble	None	Partly soluble	Partly soluble
Benzine	„ „	Partly soluble	„ „	„ „
Carbon bisulphide	„ „	None	„ „	„ „
Hot soap solution	None	None	None	None

Constant factors used throughout are: weight of concentrate used 50 gm.; water 250 cc.; crude pine-oil 1%; KCN 0·5%; CaO 1%; agitation 18 hours; fineness 150-mesh:

TABLE IV.

		Silver		
No.	Oil-solvent	Head., oz.	Tail, oz.	Extraction %
1	Alcohol	68·8	24·2	64·5
2	Alcohol ...	68·8	27·8	59·5
3	Gasoline .	61·9	24·9	59·4
4	Gasoline ...	61·9	24·6	60·0

Conclusions.—(1) Oil has no effect upon the cyaniding of ore in which the metals are not in the form of a sulphide. This shows that the trouble, in cyaniding flotation concentrate, is due to the oil-film on the sulphide particles. Furthermore, it is found that the oil has no effect upon the cyanide solution.

(2) The presence of oil in flotation concentrate hinders cyaniding because the sulphide particles are enveloped in a jacket of oil that prevents a good extraction by the cyanide.

(3) The film or covering of oil may be removed by some solvent such as alcohol, or gasoline.

(4) Heavy oils, such as pine-tar creosote, should be avoided, owing to their insolubility.

(5) Roasting at a low temperature will suffice for removing oil from a flotation concentrate containing gold, but, when treating flotation concentrate containing silver, a chloridizing roast at a low temperature must be used."—J. G. PARMELEE.—*Mining and Scienitfic Press*, Sept. 15, 1917, p. 387. (H. R. A.)

MINING.

MINING PROBLEMS ON THE RAND.—"The question may fairly be raised whether Rand mining really lends itself to the methods necessary if the full benefit of mammoth units is to be realized. Consideration of the uniformity in character of the ore indicates that so far as milling is concerned there is no difficulty; it will be more a matter of mining and transporting it economically. We must remember that the gold-bearing layers are thin. While there are stopes 15 ft. wide, it is significant that thicknesses are usually stated in inches. W. L. Honnold speaks* of 'a rough average of 33 in. which may or may not include quartzite partings.' Such a thin orebody will always necessitate a considerable length of cross-cuts, drifts, winzes, and raises per ton mined as compared with the thick, even if irregular, orebodies of other districts; in other words, the ore to be mined is scattered through a wide area. Neither is it continuous or uniformly distributed. That the valuable ore occurs in patches is now generally recognised so far as the Far East Rand is concerned. That it occurs in patches on the Central Rand is also true, although so far the individual patches have proved large and the presence of several parallel ore-beds has both disguised the real distribution and reduced the amount of sinking and cross-cutting necessary per ton, without affecting the amount of driving in banket. According to the report of R. C. Warriner for 1915, only 55·1% of the 6,150 ft. driven that year on the reef in the western section of Crown Mines showed ore of profitable grade. In the eastern section, the corresponding figure was 15·3% of 6,730 ft. In the East Rand Proprietary the percentage for 1914 was 67, and for 1915 it was 57; taking the Hercules alone, it was 10, and for the whole group to date 45%. It should be remembered that these are deep mines now. Along the outcrop and to considerable depths the ore-shoots were much more continuous along the strike. These figures, however, are not out of line with those in the Far East Rand where the Brakpan, according to Mr. Honnold, showed 50% profitable ground, and Springs for the past year has shown 53. R. N. Kotze, the Government engineer, has taken 40%

---

* Bull, A. I. M. E., August 1915.

for a safe average for that district. The steeper dip on the Central Rand increases the tonnage per acre and the total amount easily made tributary to any one shaft, but the fact remains that there is not the same opportunity for centralizing hoisting here that exists in other metal mines.

If, however, analogy be sought in another direction the situation is more hopeful. Many thin coal-beds are worked over large areas, the coal being brought to one central shaft, and, when the mine has been laid out with that in view, a surprisingly low cost is realized. The actual breaking of coal naturally costs less than in the case of Rand banket, but so long as comparisons are on a tonnage basis it is difficult to see why a bulky material such as coal should be transported and hoisted at less cost than Rand ore. It is also difficult to believe that general costs of ventilation and supervision need be greatly more in a Rand mine, even with its dust, than in a gaseous and dusty colliery. Indeed the analogy is close between the opportunities on the Rand, especially in the Far East where most of the new mines will be opened, and in a modern coal-field. In my judgment the greatest opportunity for further improvement on the Rand is in the underground work and the best chance of success, especially in the Far East where it is to be presumed that most of the new mines will be opened, is through assimilating and adapting coal-mining methods, though perhaps something could be learned from studying the mining of thin-bedded mineral veins such as the Clinton iron ores of the United States. The most striking changes made in recent years in underground practice on the Rand have been introduced from the collieries either by engineers who had had practice in them or by Rand engineers who went to them to study methods. The Consolidated Mines Selection Company, in fact, grew out of successful ownership and operation of collieries. At the Lonely Reef mine in Rhodesia excellent points in practice have been introduced from the experience of the Lewis & Marks engineers in coal mining. This brings up the consideration of the third method suggested for meeting the problem of increasingly lower grade of ore, namely, improvement in technical practice above and below ground.

The major operations of mining involve breaking and loading the ore, transporting it to the shaft, and hoisting it to the surface. The first step involves drilling, blasting, shovelling, and takes somewhat different forms as between development-faces and stopes. Incidental to the mining itself there must be subsidiary services designed to protect, ventilate, drain, and illuminate the workings, all of which involve supervision. The rock mined on the Rand is 'the hardest on earth.' Rand miners and engineers will admit this themselves. Curiously enough 'the hardest rock on earth' also occurs in the Lake Superior mines, at Treadwell, Alaska, at various points in Canada, Mexico, Australia, and, in fact, at most of the mines it has been my fortune to visit. At each, unimpeachable local evidence can be brought forward to sustain the claim. Indeed the Rand banket, a thoroughly silicified conglomerate, is hard, but it may be questioned whether it is so hard as to make it out of the question to hope for a higher drilling speed. According to figures presented to the Economic Commission by the Chamber of Mines, the average footage per machine-shift is 21½ ft. Allowing 45 minutes per 6-ft. drill-hole it was estimated that the actual average drilling occupied 2 hours and 41 minutes, including the time taken in changing bits. There would seem to be room here for improvement in increasing the effective working-time, also possibly in increasing the speed of drilling. The air-pressure used for drilling on the Rand is about 80 lb. and miners believe that at higher pressure neither drills nor steel would stand up. Drills, of course, can be built for any reasonable pressure and are regularly used at 100 lb. and more in many mines. On the Rand the wings of a bit are subjected to great abrasion, especially in the case of hammer-drills where the action is similar to grinding on a stone. It is not easy to get drills that follow because of quick loss of gauge. The main difficulty with drill-steel is probably due, to an unsuspected degree, to poor or rather irregular blacksmithing, though this is being greatly improved by the use of drill-sharpeners. Loss of drilling-time is in no small measure due to inadequate supplies of steel, poor organisation of delivery, and faulty tempering. By close attention to these details, coupled with the use of but one type of drill in the mine and that the water-drill, at Modderfontein Deep, a marked improvement on general practice has been made and while with native labour perfection is not to be expected, improvement may. In an excellent little book called 'Practical Mining on the Rand' and in an article in *The Mining Magazine* of August, 1915, E. M. Weston discussed drilling problems in such great detail that little remains to be said. He has also made pertinent suggestions for changes in the work. It seems probable that under Rand conditions improvements in this department can only be expected through patient and unremitting attention to small details and that the gain will be slow. In other words, there does not seem to be any opportunity for revolutionary introduction of machinery or methods such as that of the one-man drill in the Lake Superior copper mines.

In blasting there has already been marked reduction in cost as an incident to the war. Finding it impossible to get materials for making the explosive that had been previously used, substitutes were offered and with slight changes in method of work the new explosive was found to give as good results at less cost. The whole list of stores purchased has received careful study since the war began and in several directions it has been found possible to economise.

In driving a development face, the cut and the round are often blasted on separate shifts. This is done in order to avoid the necessity for men going through the dust to the face to charge the round after the cut has been blasted. It has the advantage that the remaining holes can be placed to better advantage after the miner sees just what the cut broke, but has the disadvantage that progress per face is a trifle less than half what the usual plan would allow, and to secure the same development there must be a much larger investment in main haulage-ways, deep winzes, and other principal passages. In view of the fact that not more than one drill-shift in 24 hours at a face is permitted in Rand mines the rate of progress, even with normal organisation of work, would be slow. It is not to be forgotten that the serious handicap to deep mining is the slow rate of development, having in mind the heavy initial investment in shafts. While development is charged off usually at 2s. 6d. per ton, the cost of advance-tonnage prior to milling is about 4s. in the case of deep mines. Even after the mill is erected and in operation the bringing of ore into reserve is disappointingly slow and expensive; and it would perhaps not be too much to say that this is the most critical factor from a technical point of view as regards the future of deep mining. Every effort is made to push development; the slow speed is due in part to the physical conditions and in part to the regulations, which prescribe the manner in which work must be conducted. Any plan that will decrease the footage necessarily held in reserve is worth considering and there would seem to be an opportunity here for the 'delay-action' fuses used in other districts. With them both cut and round can be blasted in sequence without any one going into the dust. The same result can be accomplished, although not so satisfactorily, by cutting fuses to different lengths and firing blast and round at the same time. This is done at some Rand mines. Making it the rule to drill and blast the whole round on a single shift would virtually double the rate of progress at each development-face and so reduce by one-half the number necessary to keep going at one time. It will interest miners in other regions to learn that it is not uncommon for a stope-face to progress only 4 ft. per month. This slow rate of progress entails a heavy overhead cost per ton.

After the rock has been broken in drift or stope, it costs about 2s. 2d. per ton to shovel (or 'lash,' as it is locally called) it down the slope, into the boxes, and to haul it to the shaft. In view of the confined space in the workings there is little hope of introducing mechanical shovelling and it is only in special situations that conveyers are economical. In the future mines of the Far East Rand the best plan will doubtless be to convey the trucks direct to the face as is customary in coal mining and as has been described by Mr. Honnold in the article to which reference has already been made.

In stoping, one of the items of expense is the support of the roof. On the Central Rand the roof is so good that it will stand over wide areas for long periods. Indeed the great size of the open stopes is at once a matter of surprise and apprehension to visitors. That the apprehension is not entirely without justification is indicated by the earth-tremors that have become fairly frequent at Johannesburg. These have their origin in the caving of old stopes. Sand-filling is being employed at a number of properties with excellent results and may be expected to become a regular feature of practice in the deep mines where the dip is steep. It is to be regretted that the method was not introduced earlier, for wide areas of old workings now exist where any general settlement once started cannot be controlled and loss of the remaining part of the mine will probably result. The method of filling with sand has been described in detail by W. A. Caldecott and O. P. Powell.*

In the flat-lying beds of the Far East Rand, sand-filling through bore-holes is not practicable, and in the deeper mines the roof is weak and troublesome. It is held by using 'dry' walls, by 'cribs' of wood filled with waste rock, or by leaving pillars. Each method is expensive and unsatisfactory. Where cribs are built they must cover from one-fourth to one-third of the area of stope and as the weight comes on them they squeeze down so that they are best of temporary value. Part, but not all the timber can be recovered when the stope is abandoned. Fortunately the ore over much of the Far East Rand is so distributed that the workable bodies form a series of irregular bodies, which in the Brakpan are so distributed as to form natural panels separated by permanent ribs of barren ground. These ribs are of such size as to preclude danger from a general squeeze. The general plan of operations at the Brakpan is to cut across the course of these oblong patches of ore with the main cross-entries, make rises through them from level to level, and then stope from both sides of the rises to the limits of profitable ore. In the other mines the patches of ore are cut by drifts and winzes as circumstances dictate and then worked outward from these passageways. It is in this last phase of the work that pillars are left or packs built, in the effort to take the ore as clean as possible while the face advances. The question arises whether it would not be more profitable instead to drive from the rise a series of roads laterally to the boundary of the patch of ground to be worked, connect them at the ends, and then work back to the main rise by retreating long-wall methods. Where the roof is favourable this would obviate the necessity for any packs, would use the weight to best advantage in bringing down the rock, and would keep the men under cover. As against advancing work with small pillars it is to be remembered that in coal mining it is a rule that the maximum profit is won from doing the minimum amount of mining on the advance, that it, the most profitable pillar is larger than the one used merely to support the roof. Even under poor roofs it is a question whether more ore might not be mined on the Rand when retreating. The proposed plan would require a larger investment, but it would render the workings safer and it should prove economical. To test the matter would require careful figures based upon actual experience at a particular mine.

(To be continued.)

MISCELLANEOUS.

Saldanha Bay Phosphates.—"The following table gives three analyses of average phosphate from Constable Hill by Dr. R. Marloth, collected by himself in 1912, and six analyses by Mr. E. V. Flack, of samples specially selected by the writer in 1917, each illustrating some peculiarity in composition or in mode of occurrence. For the calculated compositions given herewith, the author is alone responsible.

Table of Analyses.

1. Phosphates from Constable Hill. By R. Marloth, Ph.D., 1912.

	A.	B.	C.
Silica and insoluble matter	38·94	36·71	25·12
Phosphoric oxide	27·24	28·11	32·63
Oxide of Iron	9·21	8·71	8·73
Oxide of Aluminium ...	16·11	14·48	17·29
Lime	1·09	1·71	3·06
Approximate composition (calculated) :—			
Phosphate of Iron	17·38	16·38	16·44
Phosphate of Aluminium ...	31·24	32·67	38·42
Phosphate of Lime ...	2·00	3·14	5·61
Silica and Insoluble matter	38·91	36·71	25·12
Oxide of Aluminium ...	3·05	0·82	1·23

**Jour. Chem. Met. & Min. Soc., S.A.*, Sept. 1913.

II Phosphates from near Hoedjes Bay. By E. V. Flack, F.C.S., 1917

	D.	E.	F.	G.	H.	I
Silica and Insoluble matter	77·05	17·62	15·67	19·29	45·51	52·87
Phosphoric Oxide	9·70	10·08	22·62	17·08	18·10	12·23
Oxide of Iron	2·82	3·36	38·86	11·96	2·60	2·61
Oxide of Aluminium	1·18	8·41		2·60	9·31	5·32
Lime	0·42	2·14	0·48	2·08	5·78	6·26
Water at 110° C.	4·16	8·05	4·90	3·56	7·15	6·89

Approximate composition (calculated) :—

	D.	E.	F.	G.	H.
Phosphate of Iron	5·29	6·30	10·10	21·97	4·88
Phosphate of Aluminium	10·00	9·18	30·00	6·22	18·80
Phosphate of Lime	0·77	3·95	0·84	3·84	10·65
Phosphates of Alkalies	2·18	not deter.		(2·00)	not deter.
Silica and Insoluble matter	77·05	47·62	15·67	49·29	45·51
Oxide of Aluminium		4·60	19·00		1·46

Sample D contained 5·48% of potash and 3·74% of soda

Comparisons with Other Mineral Fertilizers.—The fact that the phosphoric oxide is principally in combination with alumina and iron, and not with lime, has caused certain chemists and agriculturalists to profess some doubt as to the value of the Saldanha Bay rock as a fertilizer.

Dr. Juritz, however, has given his opinion that, directly applied, the material, *if finely enough ground*, would have distinctly beneficial results upon certain soils poor in lime and phosphoric oxide, and particularly upon some of the Cape soils. At the same time he pointed out that the value of the article would be much enhanced were its phosphoric oxide rendered more soluble. It must not be overlooked that the estimation of the 'available phosphoric oxide' in a fertilizer is made by extracting with a solution of ammonium citrate, since the action is generally considered to parallel very closely the natural process of abstraction of the phosphoric oxide from the soil by growing plants. Judged by this standard the Saldanha Bay rock fails, as it is generally quite insoluble; one of the samples tested in 1909 gave a return of 1·64% only. It is remarkable, however, to find that one of the Weenen (Natal) phosphates examined in the Capetown Laboratory with 34·92% of lime and 25·73% of phosphoric oxide only gave 1·15% soluble in citrate solution, and the fertilizing qualities of this material have been fully proved (see below).

Many chemists have severely criticised the validity of this reaction, however, and one of the latest investigators, Mr. G. S. Robertson, M.Sc.,* has shown, in the most conclusive manner, how artificial and grossly unsatisfactory this so-called 'test' is. He has proved that by repeated extraction with citrate solution all rock phosphates keep yielding up their phosphoric oxide, and that even apatite, the most insoluble of them, and which based upon a single treatment would show an extraction of only 1·25%, gives up 7·22% in five treatments, the last one furnishing 1·3%. He has shown that the rate is dependent to a great degree upon the fineness of the material treated, while Wiley has pointed out that temperature has a very considerable effect as well.

In the Cape Province, most unfortunately, the importation of natural rock phosphates has been throttled by the adoption of the citrate 'test,' one that has apparently been devised in Germany for the purpose of enabling that country to supply the markets of the world with highly citric soluble basic slag. Enormous quantities of rock phosphate and apatite are consumed annually in North America, materials which it would hardly pay to import into the Cape under the regulations in force. The sooner, therefore, their importation is encouraged the better it will be for agriculture in the Union.

Good results were obtained at the Cedara Agricultural College in Natal† with low grade Weenen phosphates, analyses of which give amounts varying from a few up to 8% of total phosphoric oxide; values from 20% to over 35% have also been obtained, but these are from small and generally picked samples.‡

These phosphates, which are found as nodules or in thin layers in the Upper Ecca shales, are said to be high in alumina and iron, but although these bases appear in the analyses, there is always sufficient lime present to hold all the phosphoric oxide present after first deducting that portion which is in the form of carbonate; this will appear on working out the four analyses, A, C, D, and E, published by A. Pardy, F.C.S., in 1908.**

Hence the Natal phosphates are not strictly comparable with those from Saldanha Bay.

C. G. Hopkins describes the Florida 'soft rock-phosphate' as containing chiefly phosphates of alumina and iron, but its value as a fertilizer receives explanation from Wyatt,†† who remarks that the objectionable iron and alumina are chiefly present in the form of clay held in the interstices of the rock, and that nearly all of it can be removed by washing in water.

The deposits of Lahn, in Nassau,‡‡ which exist as concretions in clay overlying Devonian limestone, carried on an average from 10–18% of phosphates of alumina and iron, and from 54–62% of that of lime, but are no longer being worked, owing doubtless to the extensive discovery and marketing of rock phosphates with not more than 3% or 5% of alumina and iron, and consequently more suited for the manufacture of superphosphate.

A. D. Hall, discussing the various types of phosphates, including the aluminous varieties, *e.g.*, Lahn, Aruba, and Navassa, says that, when really finely ground, they are effective on soils retaining plenty of water, especially when used in conjunction with ammonium sulphate, since the latter helps to bring the phosphoric oxide into solution. Again, according to Wyatt, it is generally overlooked that the phosphoric oxide normally present in the soil invariably exists in the form of phosphates of iron and alumina; moreover, the iron and alumina present in the ground exercise a transforming action upon any phosphate of lime introduced therein in both natural and artificial forms. Wiley[*] has the important statement that the natural iron and aluminium phosphates have as a rule a high degree of availability, greater indeed than apatite. Little investigation seems to have been made upon the stability of the aluminous types of phosphates, but Dr. Gilbert suspended the finely ground rock from Los Roques[†] (see earlier) in distilled water and passed a current of carbonic oxide gas through the mixture for several days. Only a trace of phosphoric oxide was found to have gone into solution under these conditions, and the same was the case when the ground rock was treated with ammonium citrate. Nevertheless, these negative experiments are wholly inconclusive as to the behaviour of the material in the soil, for, in addition to the carbonic oxide transpired from the rootlets of plants, there is also the process of fermentation of the organic matter present, while the rôle played by the various kinds of bacteria is known to be an extremely important one. Unless, therefore, experiments on the lines of those conducted at Cedara can be quoted in contravention, it would be extremely injudicious merely upon general grounds to declare that in the Saldanha Bay phosphates the phosphoric oxide is wholly in a form unavailable for plant life.

---

* *Chemical News*, Vol. 114, Nov. 24, p. 268; 1916.

† H. J. Vipond, *Agricultural Journal*, Feb., 1913, p. 288.

‡ F. H. Hatch, "The Mineral Resources of Natal," pp. 102-110, 1910.

** "Cedara Memoirs," Vol. 1, 1909.

†† F. Wyatt, "The Phosphates of America," 3rd ed., p. 78, 1892.

‡‡ Davies, "Earthy and Other Minerals and Mining," p. 1.6 3rd ed., 1892.

On the contrary, statements have already been made by several farmers as to the beneficial effects that have followed its use, but it would be well if independent support could be obtained as the results of tests made at one or more of the Government Agricultural Schools. Summing up, it appears to the writer that, although this point has not been thoroughly proved, yet there seems to be no *a priori* reason why the Saldanha Bay phosphate should not be of value as a fertilizer, but on the other hand there can be no doubt, however, that the rate at which the phosphoric oxide could be extracted by the plant would be less than in the case of normal (tricalcic) rock phosphate. The Saldanha Phosphate Company have recognized that the phosphoric oxide would only slowly become available, and that beneficial effects would not become apparent until after the end of the first year at least. They also advise mixing with nitrogenous manure, and are therefore supplying a product with which is incorporated a certain proportion of whale-guano.

In both their own interests and those of the farming community, it would be well if they placed on the market the phosphate treated according to Marloth's method, or some other modification of the latter, as the phosphoric oxide would then be almost wholly in combination with lime, and in a form suitable beyond doubt for promoting plant growth.

. . . .

The Chemical Treatment of the Rock.—In order to get over the difficulty as to solubility, Dr Marloth has devised a method of chemical treatment somewhat upon the lines adopted in the manufacture of the Wolter phosphate. For the latter there are melted together 100 parts of phosphorite, 70 of acid sodium sulphate, 20 of carbonate of lime, 22 of sand, and 6 or 7 of coke; the melt is run into water and finely powdered, the phosphoric oxide of the product being almost wholly soluble in citric acid solution. In Marloth's process 100 parts of the finely ground rock are mixed with about 10 of (dried) sulphate of soda, 20 of common salt, and 40 of finely ground limestone, and the mixture is formed into briquettes, which are burned in a kiln at a red heat for a few hours and then ground into fine powder; it is important to note that the material is never raised to fusion point, and that the briquettes resulting are not vitreous but porous, and therefore can easily be ground so as to pass through a mesh of 100 to the inch (linear). The inventor claimed that, starting with a rock containing 23% of phosphoric oxide, he was able to obtain a product with 20% of total and 18% of citrate soluble phosphoric oxide, and that in certain cases the whole of the phosphoric oxide had been converted into the soluble form. On a larger scale and with less finely ground rock, a solubility of 17% or 18% was to be expected; the product in fact would now be very closely comparable with Basic or Thomas' slag. Dr. Juritz carried out an investigation of this patented method, and found that at a bright red heat the soluble sodium compounds added prior to treatment had, as Dr. Marloth claimed, been entirely volatilized in the furnace or had been converted into another state, the whole of the chlorine and sulphuric oxide had disappeared, while a very considerable proportion of the phosphoric oxide was now in the citrate-soluble condition. It thus became evident that a fertilizer, possessing from 12% to 14% citrate-soluble phosphoric oxide at least, could certainly be produced from the Saldanha Bay rock by this method of treatment. The converted phosphate again could by the addition of sulphuric acid be changed into superphosphate, and thus become water-soluble, but there would always be the great danger of 'reversion' into the tri-basic variety, more especially in view of the presence of aluminium and iron compounds.

This retrogressive action in superphosphates is very prone to occur upon admixture with certain other fertilizers, or with carbonate of lime or the oxides of iron or alumina, as shown by G. Gray[*] and E. V. Flack[†], although some authorities, *e.g.*, Wyatt, uphold the value of 'reverted' phosphate.

As regards other possible uses for these aluminous phosphates, Davies states that the Alta Vela rock was used for the production of alum with impure phosphoric acid as a by-product that with ammonia and other fertilizers might be worked up into chemical manures. Prof. B. St. J. van der Riet has suggested to me that at some future date the material could more efficiently be utilized by being introduced into the blast-furnace during the smelting of iron, whereupon a highly phosphoric pig would be produced, from which in the ordinary way basic slag would be obtained." Dr. A. L. du Toit.—Union of S. Africa, Dept. of Mines, Geological Survey Memoir, No. 10 (Govt. Printer, 2s. 6d.), July 20, 1917, pp. 20-1-7-8-9-30. (W.A.C.)

---

[*] H. W. Wiley, "Principles and Practice of Agricultural Analysis" Vol. 2, p. 121, 1908.

[†] *Zeitschrift fur praktische Geologie*, p. 92, 1895.

[*] "Report Australasian Assocn. Adv. Science" for 1904, p. 158.

[†] *South African Journ. Science*, Vol. 13, p. 201, 1916.

THE LIMITATIONS OF THE BALANCE.—"About three years ago the author had occasion, in the course of a research, to make accurate weighings extending over some months. The balances used were by the first makers, and the discrepancies observed were at first attributed to the errors of experiment arising from the difficulties of the research. Slowly and reluctantly, however, the conclusion was drawn that the errors lay in the balances themselves, and the following is an account of the nature and extent of these errors.

It is usually accepted that a good balance carrying 200 gm. in each pan should turn with certainty with 0·1 mgm., an accuracy of one part in two millions. Much higher accuracies have been claimed, but for the purpose of the research in question this degree of accuracy was sufficient. It was assumed that it could be obtained without difficulty, and the research was started on this assumption. As has been mentioned above, the cause of the error was not at first suspected, and after many months of work the balances themselves were critically tested. It may be stated at once that all were usually accurate over a short period of a few hours or even a few days, but over longer periods of a few weeks or months they showed themselves untrustworthy.

In all, six balances were used, three being provided by the kindness of Professor Pope at Cambridge; the other three were at the laboratory in the author's house.

Those at Cambridge were a Sartorius carrying 200 gm. in each pan, a smaller Sartorius carrying 100 gm. in each pan, and a Bunge, preferred by the late Prof. Ewing for his own work, carrying 100 gm. in each pan.

Those in London were an Oertling carrying 200 gm. in each pan (and it may be remarked that the beam used was selected out of five by the makers as the best they had), another Oertling with a load of 100 gm., and a modern Bunge carrying 200 gm.

Each balance could be read with accuracy to 0·1 mgm., and in all cases standard weights were used.

All proper precautions were taken to secure uniformity of condition.

Four of the balances were used in their own case, one in a massive gun-metal case, which was air-tight, and one in an all-glass case, which was also air tight.

In each case twin weights were used so as to prevent errors creeping in from this cause.

Weighings were made by three independent observers at both Cambridge and London, and as there were far too many to record in full in a short paper, only those representing the maximum variations are recorded.

The figures show that six balances of the best make, observed by three people at two different places, gave a variation over as short a period as four months varying from 0·4 to 1·6 mgm., and that these variations cannot be correlated with any variation of external conditions.

The author is well acquainted with earlier work by Poynting and others, and does not doubt that accurate readings can be made over a short period, but finds that constancy cannot be relied on over as short a period as four months.

The natural suggestion of the cause of discrepancy is that there is a difference of temperature between the two arms of the beam. This has been dispelled by direct observation. Two thermometers reading 0·01° were placed one on each pan of a balance in the same room as that containing the three balances used in London. Except in one instance, when by accident direct sunlight fell on the bulb of one thermometer, no greater difference than 0·02° was observed. Calculations, confirming those of Landolt, show that such a difference of temperature in the beam itself is neglible in its effect on the indications of the balance, and this difference, which represents that of the pans, is far greater than would be possible in a solid piece of metal, like a beam under normal conditions. As the fact remains that these variations occur, however, there clearly must be a physical cause. The matter has been referred to engineers of eminence, accustomed to consider stresses, and one was so good as to compute the stresses in a beam identical with that of two of the balances. He reported that the beam was amply strong to carry a load without flexure, although condemning the design as clumsy. The slow flow of metals under stress is well known, and might provide an explanation were it not that the beam of a balance is not under stress except in the short time of weighing. Moreover, some permanent set in one direction or the other might be expected.

It remains to consider other probable causes of the inconstancy observed.

There may be an alteration in the effective length of the two arms of the balance. In the case of the six balances examined, two had their end knife-edges set in sealing wax, two were held by set screws, and the other two were apparently pressed in. In all three methods of construction, fortuitous movement of the knife-edge is easily conceivable, and to this explanation the author inclines.

As a balance of the best make is generally regarded as capable of use to its assigned limit of accuracy, chemists generally have accepted its indications without question. The present inquiry, which only arose out of the main research, shows that this view is untenable if constant readings are to be expected over a relatively short time. Nor is there any indication as to when the variations may occur. As many chemical and physical experiments are necessarily lengthy, an unsuspected alteration of the indications of the balance may in the past have led to grave errors. It seems to be incumbent on balance makers to provide an instrument capable of carrying 200 gm. in each pan turning with certainty to 0·1 mgm., and dependable in this respect for a reasonable time—say a year—without alteration or readjustment, it being always understood that all proper care is taken in using the instrument. At the time of writing, it appears that such a balance does not exist."—BERTRAM BLOUNT.—*Journal of the Chemical Society*, November, 1917, p. 1035. (A. W.)

Changes of Address

CLARENCE, G. J. A., *t/o* Jeppes; P.O. Box 1167, Johannesburg.

POWELL, O. P., *t/o* Germiston; P.O. Box 67, Johannesburg.

WEINBREN, M. (*from Active Service*), 129, Sivewright Avenue, Doornfontein, Johannesburg.

WOOD, S., *t/o* Barberton; P.O. Box 147, Krugersdorp.

APR 15 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII. FEBRUARY 1918. No. 8.

Proceedings
AT
Ordinary General Meeting, February 16, 1917.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 16th February, 1918, Mr. H. A. White (Vice-President), in the chair. There were also present:—

19 Members: Messrs. H. R. Adam, H. C. Hilton, F. Wartenweiler, F. W. Watson, John Watson, Dr. W. A. Caldecott, W. R. Dowling, A. McA. Johnston, Jas. E. Thomas (Members of Council), R. W. Bennett, D. M. Ferguson, C. J. Gray, W. H. Jane, J. M. Neill, S. Newton, C. Rowe A. Thomas and J. Thorlund.

8 Associates: Lieut. G. Bahrun, S.A.S.C.M.T., J. Davidson, C. L. Dexar, C. H. Olsson, H. Rusden, D. J. Thomas, H. Ward, and J. A. Woodburn.

4 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 17th November, 1917, as recorded in the November *Journal*, were confirmed.

ELECTION OF NEW MEMBERS.

Dr. W. A. Caldecott and Mr. A. McArthur Johnston were elected scrutineers, and after their scrutiny of the ballot papers, the Chairman declared the following gentlemen unanimously elected to membership:

AARDT, FRANS JOHANNES VAN, Geduld Proprietary Mines, Ltd., P.O. Dersley. Underground Manager.

MACLEN, C. A., VAN DER, Union Minière au Haut, Katanga, Elizabethville, Belgian Congo.

MACPHAIL, STUART, Geduld Proprietary Mines, Ltd., P.O. Dersley. Mine Manager.

TODD, ROBERT, Messrs. Macdonald Adams & Co., Ltd., P.O. Box 68, Johannesburg.

The Secretary: The following Associates have been admitted by the Council:—

GALLANT, WILLIAM, P.O. Box 25, Sabie. Mine Captain.

PUGH, D. W., Dynamite Factory, Modderfontein. Laboratory Assistant. *(Transfer from Students' Roll.)*

MARTIN, EDWARD M., Rose Deep, Ltd., P.O. Box 6, Germiston. Mine Overseer.

THE PRESIDENT.

The Chairman: I have to apologise, on behalf of Mr. Hildick Smith, for his absence this evening; he is away on holiday preparatory to going Home to fight in Flanders, but he hopes to be present at the next meeting.

GENERAL BUSINESS.

MERCURY.

(An Introductory Note by Dr. W. A. Caldecott on the subject was printed in the "Journal" for January, 1918.)

Mr. H. Rusden *(Associate)*: In connection with Dr. Caldecott's Note on this subject and his reference to mercury being recovered at the Witwatersrand Co-operative Smelting Works, from black sand purchased from the mines, I submit some details which may prove interesting.

Free mercury exists in black sand in two forms, which may be described as globular and floured. The tube mill, at the smelting works, discharges into a Batea-pan, which is cleaned up every six to eight hours, 30 lb. of mercury being returned to the pan when re-starting milling; this collects the globular mercury, which was originally present in the black sand. During the subsequent cyanide treatment of the black sand a portion of the floured mercury is dissolved and is subsequently precipitated with zinc-dust, together with the gold, and is sometimes present in sufficient quantity to form an amalgam with zinc-dust and gold slime, so that it seriously interferes with the regular operation of the three-throw "Deane" pump, which feeds the "Merrill" zinc press, the pump-plungers and valve-seatings being covered with an irregular coating of amalgam. The zinc-gold slime is acid treated, washed, and about 10% MnO_2 (on dry weight of material) is incorporated with the gold sludge, which is then retorted. Manganese dioxide is used whilst retorting, to avoid calcination.

The following shows the average figures, in percentage, of six clean-ups:

Zinc gold slime ex Merrill-press, 100% (containing 10% moisture).

Acid treated, retorted gold slime	16·8
Bullion obtained	5·4
Mercury	19·9

The average mercury recovered from black sand during recent months equals 2 lb. per ton treated.

A sample taken from the head of black sand residue dam showed 0·11% mercury; proving that only a portion of the mercury originally present in black sand treated, is recovered. The amalgam recovered from the work's Batea-pan usually contains lead and zinc in addition to gold and silver, consequently the retorted bullion frequently melts in the retort-trays, notwithstanding that the temperature is kept low. A useful tip in this connection is to vigorously stir the molten bullion in the retort tray as soon as it is removed from the retort, the result is a powdery mass on cooling, which presents a large surface for oxidizing agents to act on in the subsequent melting.

Mr. A. Thomas (*Member*): Among the various sources of losses of mercury mentioned by Dr. Caldecott in his contribution to the January *Journal*, I should like to make a few remarks on the losses caused while retorting amalgam.

I am inclined to think that the loss of mercury from this source is over-estimated, and that the retorting plant is debited with mercury losses which really is due to the presence of water in the amalgam, and to determine the actual mercury loss which takes place the water present in the amalgam must also be determined.

Some time ago estimations were made under working conditions to find out the amount of water present in amalgam. A receptacle was placed at the discharge end of the condensing chamber to receive the water which came off from the retort some time before the mercury, and from 39163 oz. of amalgam 421 oz. of water was recovered, equal to 1·07%—and from recent tests 12612 oz. of amalgam yielded 80 oz. of water, equal to 0·634%, which shows that the percentage of water in the amalgam is not constant.

Usually the amount of mercury called for after retorting is the difference between the weight of retorted bullion recovered and the weight of amalgam. I regret that at the present time I am unable to give any data showing what the actual mercury loss is while retorting amalgam as it would require to be taken over a period to be of any value. There should be very little loss of mercury while retorting if due care is exercised in conducting the operations insuring sufficient heat and time being allowed for the complete vaporisation, close fitting joints on the retort doors, and proper condensing chambers.

The author mentions in his paper the possibility of passing the gases from the calcination of zinc gold slime for the recovery of mercury through condensing flues and chambers or filters. Some time ago, while calcining zinc gold slime (the calciner was of the usual type generally used on the Rand with a 4 in. pipe vertically installed for carrying off the gases), we found that soon after the calcination had started globules of mercury could be seen on the surface of the gold slime. Later, as the calcination was proceeding, the mercury vaporised and passed into the 4 in. pipe and condensed when coming in contact with the cold surface of the pipe the mercury dropping back into the calcining chamber. So this process of vaporising and condensing went on for some time. To overcome this difficulty a bend was attached to the pipe together with a T piece, which prevented the condensed mercury coming back again to the calcining chamber. A cock was placed on the T piece, and after the calcination was finished the mercury was collected and weighed, close on 12,000 oz. of mercury being recovered from this source at that time. I may mention that at the particular period referred to, accumulated black sand was being treated in an air-lift vat at the cyanide works. Since then no mercury has been observed when calcining zinc gold slime or mercury recovered from the T piece attached to the pipe on the calciner. Current black sand is being periodically treated in the cyanide works, therefore it can be assumed that those responsible for the delivery of the black sand to the cyanide works together with the modern plant and appliances in use at the amalgamating rooms are taking more precautions to prevent mercury reaching the cyanide works through this channel.

Mr. A. McArthur Johnston *(Past-President)*: I would like to emphasise one point raised by Dr. Caldecott in his notes on loss of mercury. I refer to the loss during steaming. This has two important bearings, namely, mercury is lost; and secondly, the mercury volatilised by the steam floats in the air and is injurious to workmen. In some tests made by us, we found that volatilised mercury quickly settled, and was to be found in the air only so long as steam was noticed. Some means might be obtained for trapping this volatilised mercury and for conveying it away from the workmen.

Dr. Caldecott also made mention of the possibility of mercury being lost by being precipitated in the charge by soluble sulphides. This is, of course, liable to happen, but it has to be remembered that zinc and lead present in the solution will also be precipitated by such sulphides and, so far as we could find, there seems to be no selective affinity for sulphides in the case of these three metals.

Mr. Thomas has just told us of an experience of his in finding mercury in the zinc box precipitate. I was pleased to note in his remarks, however, that of late years he has found no mercury condensing in his flues. We lately tested two lots of acid treated (undried) zinc slime from two of our mines, each lot being a fairly representative sample of a clean-up, and could detect no mercury in either.

Mr. H. A. White *(Vice-President)*: With the main conclusions it is scarcely necessary to express agreement, but it may be useful to make the following remarks.

It appears unlikely that it would generally be profitable to attempt recovery of mercury from zinc-gold slime except in special cases as very little mercury would be dissolved by cyanide in the presence of soluble sulphides or thiosulphates, and, in fact, the usual lead lined vats used for treating such slime should reveal the presence of any considerable amount of mercury.[*] In the case of the black sand treated at the Co-operative smelter the presence of considerable excess of mercury enables a profitable treatment of the zinc-dust precipitate to be made, and attention might be called to similar plants in use where the solutions are separately handled. As mercuric sulphide is very readily soluble in alkaline solutions of sodium sulphide,[†] some experiment might well be made by washing such black sand residues in a 10% solution of Na_2S, and precipitating the solution with aluminium powder with a view to proceeding further if suitable results were obtained. (It might also be worth trying to pass such residues over a grease plate, as subsequently described, to determine whether any economic separation of osmiridium, etc., were possible.) Of course it is obvious that one-tenth of an ounce of mercury per ton cannot economically be recovered in any such manner. Though plate area is an important factor in mercury consumption, yet the Homestake, with about ten times the plate area per ton crushed per day compared with average Rand practice, now consumes only 0·10 oz. mercury per ton although inside amalgamation is still in use. (In 1895 Hatch and Chalmers show a consumption of 0·33 oz. per ton on the Rand, where inside amalgamation was in use.) As against the group of mines quoted by Dr. Caldecott where the mercury consumption in Troy oz. overages 7% of the amalgamated plate area in sq. ft. per ton of ore milled per day, I give a local instance where the most careful work shows 12% or more than one and half times as much. This illustrates the fact that mineral composition of the ore, especially the presence of chlorite, talc, steatite, clay and certain sulphides, may have a considerable influence upon mercury consumption; it is also obvious that the coarseness of the pulp passed over the plates is an important consideration.

It may be tentatively suggested that 1 to 1·3 sq. ft. of plate area per ton crushed per day is sufficient for maximum recovery in the mill as at present arranged, and that a proportionate reduction in mercury consumption is not probable if this be seriously decreased. As, however, this becomes true at the inferior limit it is possible that consumption may vary as the square root of the plate area.

The principal difficulty which would have to be overcome in the event of mercury supplies becoming insufficient would be the enrichment of our present closed tube-mill circuits and the lock-up of gold thereby occasioned. If blanketing were substituted for amalgamated plates, and the product were treated in the usual barrels with mercury it is uncertain how much saving of mercury would result, though there is no reason to expect any serious loss of gold if such product were finely ground and cyanided direct without amalgamation, and such a course might have to be adopted. Extra recovery of gold by blankets has been tried on the Rand—to follow the usual amalgamation—and it would be in order if we could get a description of the practice as now carried on in a few mills, but I am not aware that such methods have ever been relied on exclusively in recent times. Some experiments on this point are reported below.

---

[*] See Clennel's Cyanide Handbook, p. 260.

[†] See *Trans. Amer. Inst. of Min. Eng.*, Vol. 52, p. 165.

Upon consideration of the possibility of using any substitute for mercury it is evident that its peculiar qualities do not encourage the prospect of much success, but attention may be directed to the process in use at Kimberley and the Premier for recovery of diamonds by means of grease tables. It must be borne in mind that though the physics of amalgamation is a largely unexplored territory, that in the main the practical effect is to use preferential adhesion as a powerful means of concentration. In order to get some idea of the forces thus brought into play the following experiments were made.

A piece of mill gold was rolled flat, and a square of 2 cm. side was cut from it and mounted on wood in such a manner that a free gold surface could be suspended horizontally from the beam of a balance, and similarly a piece of ordinary banket was ground to shape to enable a similar area to be treated in the same way. Each piece has thus an area of 4 sq. cm. and an effective edge of 8 cm. A table was arranged over one pan of the balance upon which the surface to be tried could be placed, and the other arm of the balance carried the counterpoise of lead foil and the additional weights required to break the contact made. The following table gives the results obtained, and it may be remarked that free fluid surface contacts gave consistent results on repetition, but that grease or amalgamated plate figures are only roughly reliable. It appears that a gold surface exhibits greater adhesion to grease or oil than the banket surface tried, and that a thin film is very effective in accordance with the formula expressing the force with which two surfaces are pressed together by a film of liquid between them

$$\frac{2\,AT\cos a}{d} + BT\sin a$$

where A is the area of the film, B its circumference, T the surface tension, *d* thickness of film, and *a* the angle of contact.

Force of adhesion between various surfaces and gold and banket in the form of squares of 2 cm. edge.

Surface	Banket grams.	Gold grams.
Distilled water ...	1·55	1·67
Do. thin film on glass ...	8·00	15·00
Mineral Oil	1·07	1·33
Do. thin film on glass ...	13·00	20·00
Grease, 1 cm. thick on wood	60·00	90·00
Do. 0·5 cm. thick on wood	180·00	190·00
Do. thin film on wood	200·00	200·00
Do. do. under water, pressed down by its own weight at once ...	5·00	10·00
Do. do. after 5 min. ...	25·00	22·00
Do. do. after 3 hours ...		15·00
Do. do. after 16 hours ...	125·00	
Do. do. firmly pressed ...	200·00.	200·00
Mercury (clean) ...	2·00	13·00
Do. under water	—	13·00
Do. amalgamated copper	—	105·00
Do. wet do.	—	180·00
Do. do. after 5 minutes	—	180·00
Do. do. after 1·5 hours ...	—	200·00+

Grease used in the experiments is a thick dark residual from petroleum distillation, and is soluble in petrol.

Comparison of grease-plate with mill amalgamation.—

1.—A free-milling test of a screen sample assaying 9·6 dwt. showed 41·6% extraction after shaking 10 minutes with mercury. This grade would show in the mill about 50% extraction. Ten assay tons of the same material were dropped into 2 in. of water standing in a pan, the bottom of which was thinly coated with grease. It was shaken thoroughly, and immediately washed off with a strong stream of water, which took away all but a few specks which glistened on the grease and showed gold and pyrite under the microscope. The tailing caught in another pan showed practically no loss on re-weighing and showed 31·5% extraction, the bulk of the loss being recovered from the grease. The greater portion of the pyrite was not apparently retained by the grease, contrary to expectation.

II.—*Working scale test.*—

One of the three "overflow" tables attached to a tube-mill was covered over with a wooden board (4 ft. 6 in. × 4 ft. 9 in.) on which was spread a coating of grease and the usual stream of pulp was run over for 24 hours untouched. The grease collected 39 gm. of concentrate, carrying 1,250 oz. gold per ton, and the total gold represented only 6% of the gold expected on that plate.

IIb.—The experiment was repeated with the modification of removing grease and concentrate every 12 hours. The grease collected 430 gm. of concentrate, carrying 540 oz. of gold per ton, and the total gold represented 25% of the gold expected for that plate.

IIc.—The experiment was repeated with the modification of removing grease and concentrate every 2 hours. The grease collected 468 gm. of concentrate, carrying 535 oz. of gold per ton, and the total gold represented 28% of the gold expected for that plate.

A continuous grease belt system might be expected to give better results.

These concentrates show grains of osmiridium under the microscope.

Tests with canvas and blanketing.—

These tests were devised and carried out by Mr. J. M. Neill in the Geduld mill. The plate selected was one of the three attached to the "underflow" side of a tube mill, where the thick pulp carries about 40% of +90 grade and a fair amount of very coarse material. The plate was divided lengthways into three equal strips, and the pulp fairly divided between them. The middle division was covered with a strip of canvas and the two outside divisions had ordinary blanketing. In 24 hours (with three dressings) the canvas recovered 290 oz. of concentrate carrying 143 oz. of gold per ton, and the total gold represented 70% of the gold expected from its share of the plate. The blanketing recovered 574 oz. (or 287 oz. from same area) of concentrate carrying 82·5 oz. of gold per ton, or only 40% of the gold expected from its share of the plate.

These experiments are being continued, but confirm Mr. Neill's experience that canvas, though cheaper and easier to handle, is more effective than blanketing. The products are easily susceptible to further concentration.

Mr. F. Wartenweiler *(Member of Council):* With reference to Mr. White's contribution, I may state we have been carrying on quite elaborate tests with mill blankets, corduroy, and jute, but we have not yet arrived at any definite result. In a general way, the gold recovery has not been as good as a recovery on the amalgamated plates.

The Chairman: You have not tried actual canvas?

Mr. F. Wartenweiler: Yes, we have tried canvas, about which we hope to give some data later on.

Some six months ago I had occasion to have samples of black sand analysed for mercury—black sand derived from the amalgamating barrel. The amalgam had been collected after barrelling by the rather crude method of stirring up in a bucket, and the mercury content in this black sand was as high as 0·75%; from 0·45% to 0·75%, which would be from 9 lb. to 15 lb. of mercury per ton of black sand. To show the usefulness of the Batea which we subsequently installed, we brought this same mercury content in the black sand after passing the Batea, down to 0·18%, or 3·6 lb. of mercury per ton. This was on one particular mine. On another mine I had occasion to have an analysis for mercury made on the mill black sand after amalgamation in the barrel. After passing through the Batea this black sand analysed 0·06% of mercury. I treated the black sand with sodium sulphide, the idea being to dissolve any mercury in the form of mercuric sulphide. Approximately about half of the total mercury content proved to be in the form of mercuric sulphide soluble in sodium sulphide. Of course, in the case of this black sand, it would hardly be worth while to make any elaborate recovery by means of sodium sulphide and subsequent precipitation on aluminium, as practised at Cobalt on rich silver ore amalgamation.

I have also had occasion to have gold precipitate out of a strong solution extractor box analysed. This gave a mercury content of 0·15%; out of a medium box 0·25%. I did not determine mercury from the slime box, because the heads of the slime box usually go into the strong box, and I considered we would be more likely to get concentration in the head of the strong and medium box than in the slime box.

The Chairman: May I ask if on that mine where you found the mercury in the head of the strong box they were using a black sand recovery plant? Were they treating that black sand by cyanide?

Mr. F. Wartenweiler: Black sand was recovered for separate treatment.

The Chairman: And treated on that mine?

Mr. F. Wartenweiler: Yes.

Mr. S. Newton (*Member*): In connection with the steaming of plates at the "C" Section, Crown Mines, and on account of the hot vapour rising from the plate when the steam jacket is removed, a blast of compressed air was used before commencing to scrape the plate but was found very difficult to regulate during the operation of scraping.

Mr. S. H. Pearce suggested that an electrical fan might be more useful; this was tried, and has been in use for six months. It has been found very beneficial. It is placed at the head of the plate and maintains a constant flow of fresh, cool air about the level of the workers' heads, and the work is done under more pleasant conditions.

If mercury is in suspension, with the fumes rising from the plate while it is hot, the cool air from the fan would probably condense any mercury.

I cannot say that any appreciable difference in the loss of mercury would result, but from a health point it is a step in the right direction.

Mr. A. McArthur Johnston: Have you ever tried a hood over the steamed plates for exhausting the steam therefrom, and condensing any mercury floating in the air?

Mr. S. Newton: No, I have not seen that worked at all. This was merely, as I say, the outcome of bringing this compressed air and trying to eliminate as much of the mercurial vapour as possible. There is a certain amount in suspension, especially when a steam jacket has been over the plate for 29 minutes previous to taking off the cover, and to do away somewhat with the noise and probably displacing it from one part of the plate house to another, this fan was put in, and the men mostly concerned, that is, those who are working there look forward to it, and think it is something in the right direction; and we do not find so much of that sickness we had previously among those who have to do the work.

Mr. John Watson (*Member of Council*): On the subject of mercury, I may say that I have been doing the retorting on the City and Suburban Mine for the last 15 years. The method of taking the weight of amalgam put into the retorts, deducting the weight of retorted gold drawn out and figuring on the difference as "mercury due" is, I consider, a crude one. It has its use as a check, in a rough way, I admit: the difference, however, includes not only mercury but also moisture and a considerable portion of the sulphur present in the amalgam.

Moisture.—Mr. Thomas, of the Simmer and Jack, mentioned moisture in the amalgam. Well, we have a hydraulic press which gives firmly-pressed cakes; but a few years ago, when it was first installed, we used to get quite a lot of moisture exuding in the strong room from the pressed cakes. I have seen the amalgam dishes with about ¼ in. water in the bottom. That water we reject and do not weigh; but you may feel assured that just as much moisture, or even more, is left in the cakes.

To test this point of moisture in amalgam I got our manager's permission, over five years ago, to cut some cakes across the centre. A well-pressed, dry-looking cylindrical cake was taken, and I found that the moisture expelled by heating a weighed portion for one hour in an air-bath at a temperature of about 215° F. was equal to 3·02%. Now, 3% on 5,000 oz. amalgam equals 150 oz.

Some might try to argue that this was mercury coming off. I do not think so. Mercury does not begin to come off till you reach a higher temperature. I dried my watch-glass and contents again by continued heating at the above temperature, but there was no farther loss.

Indeed, in retorting, we generally have the amalgam in, doors wedged up, padlocked and begin to fire by 8.30 a.m., but the first of the mercury only begins to come over by about 10.45 a.m.

Sulphur.—So far as I know, there have been no analyses published showing the proportion of sulphur in amalgam. Black sand amalgam especially must contain quite an appreciable amount. When you draw the retorted gold and it is being cut up, amalgam trays scraped, etc., the smell of sulphur dioxide is sometimes enough to choke or suffocate the men who have to stand over it during these operations.

In the above rule-of-thumb method of calculating "mercury due," both moisture and sulphur are included with this hypothetical mercury.

Some battery managers worry a good deal over loss of mercury: now that mercury is high in price, they worry still more. The loss of mercury on retorting is small, compared to that due to flouring and mechanical losses at the mill itself.

Mr. W. H. Jane *(Member):* In regard to the remarks of the last speaker, on the subject of the steaming of plates, I should like to say, after 21 years' personal experience, that a time is reached, according to the thickness of the table, the thickness of the cover, and other considerations, when there is a certain amount of heat in the plate. If that time is exceeded one commences to lose mercury. The amalgam also becomes more difficult to scrape off.

Mr. S. H. Pearce *(Past-President)* (contributed): I am afraid I am not able to add much to the general knowledge as expressed in Dr. Caldecott's excellent note on the subject of mercury losses. Most of us have been aware of a probable shortage of mercury for some time, and those of us who depend on amalgamation for producing 70% of our gold do not relish the idea of curtailing it, or possibly dispensing with plates entirely in favour of blankets. Plate amalgamation is rather a fine art than a scientific process, and with all due deference to our millmen, who are wonderfully expert in their business, it is only a rule-of-thumb affair with lots of opportunities for carelessness and waste; and I, for one, who has to acknowledge a consumption very close to the higher figure given by Dr. Caldecott, would gladly welcome any hints to enable me to reduce this item.

The result of my own observations are not very valuable, but such as they are, I will give them:—

The chief losses of mercury are caused by the attrition of the ore particles passing over the plates which, as Dr. Caldecott says, will vary more or less in direct ratio to the amount of pulp passing over a varying plate area, and which agrees with my own experience in the three mills on the Crown Mines. One factor which has to be allowed for is the average size of the ore particle, for it is well known that beyond a certain limit the coarse pulp will strip mercury and amalgam off the plates entirely. There are, however, conditions which exist and would require a radical change in policy to alter.

The other aggravating circumstances of loss occur in many ways, and this is where the practical millman can come along with his experience. Those that I have observed are:—

- Impure mill water, or insufficient lime to correct acidity in the rock;
- Inadequacy of traps, and too long intervals between cleaning them out;
- Too generous use of mercury at dressing—this includes carelessness in using the mercury bottle and spraying elsewhere than on the plate;
- Too great a velocity of pulp, which may be due either to too high a ratio of water to rock crushed, or too much fall on the plates.

Another item which I think worthy of mention exists in the grinding of amalgam and black sand, the losses from which were mentioned by Mr. Rusden. Individual practice in the treatment of the "scrape and plate dressings" differs all over the field.

My own experience, after trying various methods, is that a smaller loss of mercury is involved by the old-fashioned method of cleaning up the "scrape" in a Batea pan and subsequently grinding the "black sand" in a barrel for some 20 hours, adding the necessary mercury only some two hours before finishing. I daresay some of the millmen will have something to say about the losses in this practice too, but I might mention that during the time I had 100 stamps out of 300 hung up, and the bulk of the scrape and black sand correspondingly less, we found that the size of the barrel charge had a substantial bearing on the amount of mercury floured in the operation, and after some experimenting we have adopted the following conditions to ensure a minimum loss:—

Speed.—A 24 in. internal diameter barrel should run at 16 revolutions.

Load.—Barrel should be at least three-quarters full.

Consistency of charge should not be more than sloppy, with no excess of water.

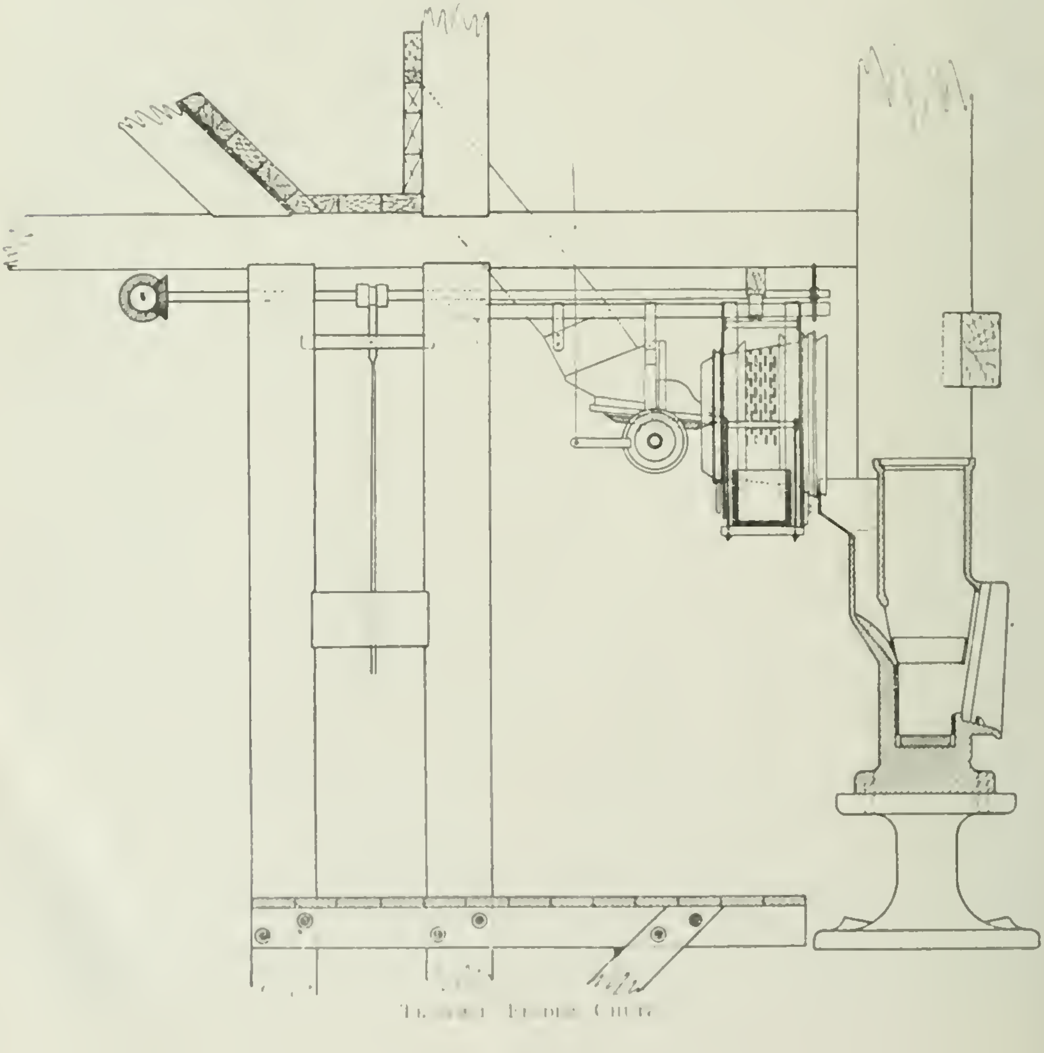
We have found that as much as 100 oz. of mercury can be floured by not attending to these conditions. I need hardly add that a liberal use of lime in the charge, to prevent acidity, is essential.

The only other thing that occurs to me at the moment is to deprecate the use of cyanide when dressing plates—which I believe still survives in the backwoods—and also to mention that we have tried to recover mercury in the traps by using a liberal amount of rusty iron nails therein. The iron certainly retained both mercury and amalgam, but I would not like to say whether the yield was much greater than we had before. Certainly it was a lot of trouble to dig out again and took a long time to clean, so we did not repeat it!

The Chairman: We have had a very interesting discussion on that point. The discussion is not closed yet and, if anybody has anything to communicate in writing, we shall be glad to publish it and also be glad to hear at the beginning of next meeting if anyone has anything to suggest, because it is a very important matter.

SEPARATION OF FINE ORE BEFORE MILLING.

Mr. E. H. Johnson *(Past-President).* In 1910 the author contributed a note to the discussion on Mr. Stadler's paper on Kick's Law (Vol. XI., p. 168), in which reference was made to certain experiments then being made to deflect that portion of the ore which was finer than the screen used on the mortar-box direct to the tube-mills. For some years past the device shown in the accompanying drawing has been used for this purpose, but as a direct determination of tonnage in cyanide works could not be



TUBE-MILL FEEDING CHUTE.

made without hanging the section of the mill not so equipped, publication of results has been delayed. An opportunity occurred recently whereby the un-equipped stamps could be "hung-up" for a fortnight and a determination of the effect of the trommels made.

The device consists of a bell-mouthed trommel 1 ft. 9 in. long, 2 ft. 2 in. diameter at the narrow end and 2 ft. $6\frac{1}{2}$ in. at the wide end, and operates as a revolving perforated chute between the challenge feeder and the mortar box. The screening on the trommel is a perforated plate with holes $\frac{3}{8}$ in. × $1\frac{1}{4}$ in., and the material passing the screen falls into a launder passing outside the Kingpost into the launder leading to the tube-mill cones. The effect on crushing is not only to eliminate from the mortar-box the material fine enough for tube-milling but also avoids the cushioning effect to the stamps this material causes. The trommels are driven through an intermediary shaft from the line-shaft and revolve at 16 R.P.M. The maintenance cost is very light, the perforated screen ($\frac{1}{4}$ in. plate) lasting nine months, and the only other parts requiring renewal are the small supporting rollers. The rate of feed is, of course, governed entirely by the challenge feeder.

The following is the data derived from the trial. The "nominal crushing unit," familiar to Rand readers is used to render comparison easy. For those unacquainted with this empirical formula a unit is a 1,250 lb. stamp, and a 22 ft. × 5 ft. 6 in. tube is reckoned as equivalent to 30 units.

Number of stamps in operation	110
Falling weight of stamps ...	1,450 lb.
Running time	... 11·2417 days
Tons milled ...	... 28,322 tons
Duty per stamp ...	... 22·9 tons
Number of tube-mills in operation	11
Running time	... 12·1356 days
Screen used, aperture	0·32 in.
Duty per N.C.U. ...	... 19·71 tons
–90 duty per tube-mill per day	...147·5 tons
–90 duty per N.C.U. per day	1·588 tons
Per cent. slime ...	... 56·1
,, –90 in pulp	... 88·1
,, –200 in pulp	... 74·0

Gradings ...	+60	+90	–90	–200
Screen grading	75·9	5·5	18·6	
Sand residues	1·7	25·3	31·1	41·6
Slime residues			0·7	99·3

Mr. A. H. Winterton was associated with me in the design of this device, and I have to thank the management of the East Rand Proprietary Mines and Mr. Graham of the Rand Mines for permission to publish these results.

AN INTERESTING PEBBLE.

Mr. John Watson, F.I.C. (*Member of Council*): This large quartz pebble, from banket, is the property of Mr. Glyn, manager of the City and Suburban Mine. About a month ago we wet it and examined it under a lens. It appeared to be coated with visible gold, though it is a very large and very white pebble. Dr. Mellor, I understand, has seen it and thought the orange-coloured coating was not gold. The matter could be settled by assaying a portion; but, meanwhile, before the specimen is broken, I shall be glad to show it, at the close of the meeting, to any of our members who are interested in the matter.

NOTES ON AN UNDERGROUND SPRING OF WATER, CONTAINING MANGANESE AND LITHIUM.

By John Watson, F.I.C. (*Member of Council*).

In June, 1917, the writer received a sample of water from an underground spring, situated on the 37th Level, East Drive, of the City and Suburban Mine. This locality is part of the claims bought a few years ago from the adjoining City Deep property.

The distance from surface is: On incline, 6,156 ft., and vertically, 3,300 ft. below surface.

The nearest intrusive dike is 700 ft. West of spring, striking N.E. and S.W. The water fault is 120 ft. W. of spring and 40 ft. E. of a large fault, striking N.W. and S.E.

The sample was first tested for suspended matter and alkalinity; but Mr. Ingle, the mine captain for that district, desired a fuller analysis to ascertain if the water were suitable for drinking.

On titrating a portion with a dilute solution of potassium permanganate (1 cc. 0·1 mgm. available oxygen) an excessive amount of some reducing, or organic matter was found to be present. On the strength of this test, they were advised not to drink the water until such time as a fuller analysis had been made.

For determination of silica, alkaline

earths, etc., 200 cc. of the water were taken, acidified with hydrochloric and a little nitric acid, boiled, filtered and washed. The filtrate was treated for alumina and iron as usual, and the lime was precipitated as oxalate. At this stage the beaker and contents were left overnight, and next morning I noticed that the precipitate of calcium oxalate, instead of being white, was distinctly darker than usual. Suspecting manganese to be the cause of this, another portion of the water was evaporated in a platinum capsule, the concentrated solution transferred to a platinum crucible cover and evaporated to dryness. Then, on addition of a little Na_2CO_3 and KNO_3 and igniting, a bright green mass of sodium manganate was obtained. At this stage the author asked Dr. Moir if he had ever found manganese in any of the mine waters of the Rand. He replied that he had not, and, as he showed considerable interest in the matter, and kindly offered to confirm or refute the presence of manganese, a portion of the sample of water was sent to him. Dr. Moir determined the manganese in the water, and also found lithium and potassium to be present in notable quantity. At his request, a larger sample was taken (on 23rd August), two litres were evaporated to dryness and sent to Dr. Moir, who kindly determined the lithium, potassium and sodium.

The following are the analyses of two samples of different dates:—

	1917 5th July	 23rd Aug.
Specific gravity …	1·0075	
	Parts per 100,000	Parts per 100,000
Total solids at 205° F.	204·5	202·1
Inorganic solids .	176·0	178·0
Loss on ignition	28·5	21·1
SiO_2, etc. (ins. in d.aq.reg)	6·13	
Al_2O_3 and Fe_2O_3 …	3·38	
CaO …	21·75	21·92
MgO …	17·50	15·95
Cl .	2·73	
SO_3	92·69	102·21
CO_2 .	7·50	
Li	—	0·23*
K	—	0·37
Na_2O	—	12·13
MnO .	5·10	4·44
Total	†172·81	

Reaction.—
To methyl orange, alkaline 11·20, 10·08 parts per 100,000, calculated as CaO.
To phenolphthalein, neutral, no pink colour given; therefore alkali must be present in the form of bicarbonate.‡
Alkalimetric test for permanent hardness (Pfeiffer and Wartha): 133·28 parts per 100,000. ($CaSO_4$ and $MgSO_4$ calculated as $CaSO_4$.)

I have not attempted to combine acids and bases accurately; but it will be seen that they fit together quite closely, as required for a neutral water.

The difference between inorganic solids and the total of the analysis amounts to 3·2 parts, and is probably accounted for by soluble combined silica (not determined), also by the fact that there was distinct oxidation of the MnO to MnO_2 on calcining.

On 23rd August, 1917, a fresh sample (consisting of two Winchester quart bottles) was taken, 2,000 cc. being evaporated for Dr. Moir, as before mentioned. Since this paper was promised, the author has checked some of the main constituents, and the figures are given in the right hand column. The check test of manganese was made last Saturday, using the method of Chatard, modified by Thorpe and Hambley, as described in Sutton's Volumetric Analysis (pp. 261-2, Eighth Edition). Instead of using PbO_2 (puce-coloured oxide) however, red lead was used on Dr. Moir's suggestion, as being more stable. It must be noted here that Dr. Moir's test of MnO was on the sample of water taken on 5th July; whereas the author's check was on that sampled about seven weeks later.

In 1879 the late Mr. H. S. Pattinson read a paper to the Newcastle-on-Tyne Chemical Society, "On a Spring Water containing Manganese in Solution." This water occurred near Riding Mill, about 15 miles west of Newcastle, and contained 0·301 gr. manganous carbonate to the gallon (0·43 parts manganous carbonate per 100,000). The City and Suburban spring, therefore, contains twenty times as much.

The water flowed from the mouth of an old disused drift made in searching for lead ore. Being clear, it had at one time been used for drinking purposes by a house in the locality. The overflow water gave a deposit of black mud, which on partly drying contained:—

MnO_2 .	62·09
MnO . .	6·91

---

* 2·3 $LiHCO_3$

† Assuming alkalies to be the same in both samples.

‡ The true reaction is very nearly neutral, [H·] being about $10^{-6.5}$

Mr. Pattinson stated that Bischof, in his "Chemical and Physical Geology," mentioned that the discharge channels of a water in the neighbourhood of Nürnberg (in Bavaria), and of a spring near the Cape of Good Hope contained similar deposits.

Prof. P. Phillips Bedson, D.Sc., read a paper in November, 1887, to the Newcastle section of Chemical Industry, "On the Composition of Certain Colliery Waters," in which he gave: 25·06 gr. lithium chloride per gallon = 35·8 parts lithium chloride per 100,000, as occurring in the Brockwell seam at Redheugh Colliery. Also, a water from Wardley Colliery was found to contain:—8 gr. to 9 gr. lithium chloride per gallon = say, 12 parts lithium chloride per 100,000.

In conclusion, I have to thank Mr. Chas. Glyn, general manager of the City and Suburban Mine, for his permission to publish results; also, Mr. Brinton, acting surveyor, for information received, and I should like to emphasise my appreciation of the valuable work and help which Dr. Moir has given in the matter.

The author ventures to hope that this little paper may lead to other South African chemists publishing analyses, which may be of interest to our geologists and mining members.

Mr. A. McArthur Johnston *(Past-President)*: I would like to propose a hearty vote of thanks to Mr. Watson for his interesting paper—interesting, if I may say so, more from a geological than a chemical point of view. What I appreciate most of all was his announcement that the water was sent to him for analysis. The usual custom is for men and natives to start drinking water coming from a fissure in the rock without worrying what its quality may be. The danger of this we have proved over and over again, as waters quite unsuitable for drinking purposes have been found even at considerable depth, and have caused illness among the workmen. Though the paper may not lead to much discussion, it is useful to have a record of it, and Mr. Watson deserves our thanks for bringing the analyses forward.

The Chairman: I am sure we are very much obliged to Mr. Watson for bringing the information before us. I have no doubt, when he replies to any discussion that may take place, he will inform us if any deleterious effects have been found in his reduction plant from the opening up of this spring.

THE MANUFACTURE OF CRUDE SODIUM MANGANATE FOR USE ON THE MINES.

By F. Wartenweiler (Member of Council).

(Printed in Journal, January, 1918.)

The Chairman: Mr. Wartenweiler will now introduce the paper published last month.

Mr. F. Wartenweiler *(Member of Council)*: When I sent in the account of our collective experience and results in the manufacture of this oxidizer for publication in the January *Journal*, I did not anticipate that the brief contribution would be raised to the dignity of a paper.

Better processes are probably in use, but the literature on the subject appears to be meagre and inexact. The manufacture of permanganate, as far as I could gather, has been brought to a considerable science and efficiency in one of the European countries. Details are evidently kept a trade secret. I have endeavoured to put down the main features of our experience so far in making the crude product. No doubt, those who choose to make manganate will find the subject in a state of evolution. The practical operations are not popular with the natives employed, or with anyone in close touch, on account of the irritating effect of the fine caustic soda which, on handling, floats about in the air. Respirators are worn during the mixing of the charge.

The general uses of permanganate on the local mines are pretty well known. Aside from use as a disinfectant and destroyer of cyanide, it is used to oxidise reducing matter in the ore treated. The effective and economical use in connection with the cyanide process is a large and prickly subject, too much so for incorporation with the description of its manufacture, and I put it aside as a story to be told another day.

Mr. F. W. Watson *(Member of Council)*: I have great pleasure in moving a hearty vote of thanks to the author for his interesting paper, and wish to congratulate him on his success in manufacturing a new product in South Africa. One or two points could with advantage be touched upon by the author in his reply. In the first place, it would be interesting to have some idea of the cost of production; what expenditure is necessary per unit of available oxygen? Then in the manganese ore he tells us there is 40 of manganese, this is rather vague, as it might mean total manganese and not simply the manganese present as MnO_2; the latter being the correct figure to give in a case of this kind. We had recently five samples of South African pyrolusite submitted which showed a content of from 60% to 61% MnO_2, or from about 11% to 12% available oxygen. This approximates closely to the author's 40% Mn.

Another point is the use of commercial caustic soda, which is an imported article. Would it not be possible to use a mixture of sodium carbonate and quick lime? In Thorpe's Dictionary of Chemistry I see it stated that this mixture is used in the manufacture of Condy's Fluid, a mixture of sodium manganate and permanganate.

I put this forward as a suggestion, as the two substances are both local products and might be substituted for the caustic soda which is expensive and, as the author has said, very unpleasant to handle.

Dr. W. A. Caldecott *(Past-President)*: I desire to support what Mr. F. W. Watson has said with regard to the valuable data furnished by the author upon the production of one of our requirements.

I should, however, like to ask the author whether it would not be cheaper to use sodium nitrate in place of the potassium nitrate employed by him, the former being readily procurable?

THE NATAL COALFIELDS—PHASES IN DEVELOPMENT.

By Wm. Taylor Heslop (Member)

(Printed in Journal, May, 1917.)

REPLY TO DISCUSSION.

Mr. Wm. Taylor Heslop *(Member)*: I am pleased to have the opportunity of thanking Mr. C. J. Gray for his kind and generous remarks and references, which bring to mind many a pleasant meeting of long ago, when geological and mining problems, as well as mining legislation, formed topics for friendly discussion, as we watched the coal industry gradually develope from babyhood to adolescence.

The term "Ecca Shale" was originally applied to the hard blue shales, which break up into characteristic granular fragments, and are very widespread through South Africa. Throughout the Vryheid district there is very conclusive evidence that these shales underlie the coal measures. In the Dundee and Ladysmith districts, owing to some severe faulting, the evidence is not so clear. Moreover, there is no unconformity between the Ecca Shales and the coal measures, and therefore geologists are justified in grouping the two formations into the one series, which they now generally term the "Ecca Series." I quite agree with Mr. Rowland Gascoyne's reading of the Vereeniging measures, where the coal seam lies within a few feet above the line of unconformity which marks the conclusion of the Dwyka age, and where the Ecca Shales are missing. The absence of the shales together with the non-glacial overlying conglomerate misled Mr. E. J. Dunn and many of the older geologists regarding the true horizon of the coal.

With reference to the effects of the dolerite intrusions, I have noted coal that has been converted into anthracite by underlying intrusive dolerite in several places. I have also found overlying sandstones in direct contact with the dolerite, converted into quartzite by the heat from the igneous rock. There can be no doubt whatever that the sheets are intrusive. Where the sheet underlies the coal, we find the coal seam elevated above its normal horizon to a height equivalent to the thickness of the intruded dolerite sheet.

Mr. E. M. Weston raises the question of coal reserves. In Vryheid extensive developments are in progress, and reserves of coal considerable, but even there the coal is only found in the hills, and not 5% of the Vryheid district is coal bearing. Of that 5% of coal bearing area, probably the proportion of bituminous coal is greater than in the Dundee district.

Extensive borings have been made beneath the group of coal seams presently being worked. The lowest workable seam in the Vryheid district is probably the same as a thin seam, which lies about 70 ft. below the main seam of Dundee district, and in the latter district varies from 2 in. or 3 in. to 2 ft. in thickness. With that exception very little coal, and none of workable thickness has been found in boreholes ranging up to 800 ft. below the presently worked seams. When we get below that into the typical Ecca Shales nothing more than an occasional inch or two of coal has ever been found, and in the Midlands of Natal, exposures of the Ecca Shale are extremely frequent, and the likelihood of coal most improbable. Patches of the upper or coal measure beds have been found near Estcourt and Mooi River, in Greytown district, on the Tugela twenty miles below Colenso, and at Brakwal on the Harrismith railway line, but no coal of value. On the Coast there is a patch of coal measures near Umhlali, and again several areas including coal seams of poor quality in Zululand. None of these are promising, and when once it is acknowledged that the Ecca Shales underlie the coal bearing measures, it must be admitted that the prospects of finding new fields are extremely remote.

As regards machine cutting, this was first introduced into Natal in a time of scarcity of native labour, and it was sound business at the time to save on native labour, even if no saving in working costs ensued. Conditions are much too variable for making any general comparison between different types of machines, or against hand work. The machine scores when a crowd of raw natives is brought to the mine, and can be quickly used to advantage on tramming and shovelling instead of slowly learning to use the hand pick. On the other hand, in pillar extraction, in very soft coal, or in very thick seams, the advantage generally lies with hand labour.

Regarding coal waste, Mr. Weston must not for a moment assume that Natal is the only bad boy of the South African family. As far as I know, Natal is the only Province where the coal pillars are being systematically extracted. If pillars are left too small for extraction they are irretrievably lost. In Natal the principal waste is due to the non-working of a second seam lying from 2 ft. to 6 ft. distant, and its successful total extraction is by no means an easy task.

In the Transvaal there are big areas of pillars left, which are too small to be ever successfully extracted. Whether in Natal or Transvaal the coal is a National asset, and the Government is the responsible trustee, whether for use or waste.

THE CONSTRUCTION AND MAINTENANCE OF SLIME DAMS.

JAS. E. THOMAS (Past-President) and
E. A. OSTERLOH (Member).

(Printed in Journal, June, 1917.)

DISCUSSION.

The Chairman: We next come to discussion on the Construction and Maintenance of Slime Dams, which should again be a subject of very live interest. Perhaps the members present prefer to say nothing about their experiences of slime dams!

Mr. S. Newton *(Member):* One thing I think might be cleared up? What are dams?—slime dams or water dams? As a reduction man, I think we should have that matter cleared up. We all take it to heart when it is slime dams, but when we see in the paper that three dams have burst at the Crown Mines, due to the recent heavy rains, we naturally think it reflects on us. There is a difference between a water dam and a slime dam.

A METHOD FOR FURTHER REDUCING CYANIDE AND ZINC CONSUMPTION.

By R. C. H. COOKE, F.C.S., A.I.M.M. (Lond.) (Member).

(Printed in Journal, August, 1917).

DISCUSSION.

Mr. A. King *(Member):* It must be disappointing to the author that the discussion on the important subject with which his paper deals has been so meagre, and it is to be regretted that our *Journal* is not to be enhanced with, and the members of our Society are not to have the benefit of, the opinions of those who have experimented with, and it is said, considerably reduced their previous consumptions of cyanide and zinc.

From the writer's somewhat limited experimental work in this direction it would appear that to maintain satisfactory extraction and precipitation it will not be an easy matter to reduce the cyanide consumption in the ordinary type of plant below 0·25 lb. per ton of ore treated. It has been found by reducing strong sand solution 25% in strength precipitation and extraction remained satisfactory, but on account of interchange of final wash solution between sand and slime plants the amount of solid cyanide required to maintain equally good results in the slime plant had to be considerably increased, with the result that a "disappointing small effect on the total consumption" (as referred to by Mr. White) was found: namely, 1·5%. There would appear to be a greater field for saving zinc by reducing the quantity of solution to be precipitated to a minimum, and by returning as much zinc to the boxes as the exigencies of clean-up will allow. The consumption of both zinc and cyanide must be considered together along with the cost of treatment, precipitation and clean-up before one can arrive at the limit of economical extraction. In this connection it is to be noted that an increase of 0·02 dwt. per ton in the value of precipitation solution means, in the ordinary type of plant with decantation slime treatment and treating 50% sand and 50% slime, an increase in the residue per ton of ore treated of roughly 0·01 dwt., equivalent to 0·01 lb. of cyanide under present conditions.

A LOGARITHMIC CALCULATOR.

By D. R. Robinson (Associate).

(Printed in Journal, September, 1917.

Mr. J. Thorland *(Member)*: Although the calculation of tonnage is a comparatively brief operation after the somewhat lengthy one of estimating width and value, any method tending to shorten same is to be welcomed. The author's assumption that "if the Brunsviga had never been invented, our surveyors would be using four figure logarithms and antilogarithms for this class of work" is likely to prove misleading, as the ordinary 10 in. slide rule is used on some mines with perfectly satisfactory results. For examining the author's equation

$$T = \frac{K \times W \times \text{Sec Dip}}{12 \times n}$$

in the light of the conditions on any individual mine, we have K falling into class (b) with n, while "Sec Dip" would be transferred to class (c), leaving us with only two variables P and W. A factor table is calculated in a few minutes by multiplying $\frac{K}{12 \times n}$ by the secants of the degrees of dip desired; *e.g.*, with scale 1:500, planimeter set to "square inches," dip 30°, we have $\frac{1736}{144} \times 1{\cdot}1547 = 13{\cdot}92$. Multiplying this by P and W consecutively on the slide rule is the work of a moment, and has this further advantage that the first operation supplies the stope width factor $\frac{T}{W}$, which is required later for summarising.

The author's remarks on the consistency of work with accuracy of calculating instruments are sound, and might be extended in other directions, *e.g.*, with regard to tables. Many of our surveyors still use seven figure tables in the calculations of underground traverses, where five places are more than sufficient. The calculator would probably be found of greater value in a central office than on a mine, where the advantages claimed would not appear to have been established.

ELECTRIC FURNACE MANUFACTURE OF SHOES AND DIES ON THE WITWATERSRAND.

By Geo. H. Stanley, A.R.S.M., F.I.C., M.I.M.M. (Past-President),

and

ELECTRIC STEEL-MELTING PLANT.

By Prof. W. Buchanan, B.Sc., A.R.C.S., M.I.E.E. (Past-President, S.A. Institute of Electrical Engineers).

(Printed in Journal, September, 1917.)

DISCUSSION.

Mr. W. H. Jane *(Member)*: The following remarks on the behaviour in use of the shoes and dies made by the Witwatersrand Co-operative Smelting Works, Ltd., may be of interest to the authors and the members of the Society.

At the Simmer Deep-Jupiter mill, during the year 1917, 115 shoes and 100 dies were used. Both shoes and dies were numbered at the smelting works, and before being brought into use, the weights were checked on the mine scales. They were put into the batteries, and the positions 1, 2, 3, 4, 5 corresponding to the numbers on the shoes and dies were marked on the sheets supplied. Every week each set of dies was taken out of the mortar boxes, cleaned, weighed, and the loss of weight noted. The loss was fairly regular in all the dies, and considering that each die was returned always to its old position, whereas in imported dies No. 3 sometimes replaces No. 1, and so on, the weights of the discarded dies are remarkably regular. A number of the dies broke round the outside edge about ½ in., as if the metal were chilled and brittle, but otherwise wore very smoothly until discarded. Five only broke, ranging from a life of 37·2 to 85·7 days. Four others had one corner of the base broken during the first week, but were none the worse, and wore down without any further trouble. A few wore irregularly, a large hole developing from the centre, basin shaped, similar to the manner in which dies wore in the days of fine mesh screening. This rectified itself as the dies wore down, and when nearly worn out were of good shape. The first lot of dies delivered were rough in casting, and near the base were full of blow holes, but none of the dies broke. The life of the dies tried, worked out at 79·3 of the life of imported dies of equal weight.

The shoes supplied were treated in a similar manner, but instead of being weighed, were measured weekly and the loss of length noted. The shanks of part of the first consignments, which were broken, were badly honeycombed with blow holes, but the shoes delivered from December, 1916, to February 28th, 1917, show only 34 broken shanks against 35·6 of later consignments, when blow holes were not so much in evidence. The life of shoes delivered during that period, however, show only 51·5 of the life of imported shoes of equal weights, against 58·4 for the whole. The difference in the loss of shoes working in the same mortar boxes was very marked, differences of 21·5 days in a total of 60·3 days occurring, whereas the dies wore very evenly.

At the Simmer Deep-Jupiter mill an 8 in. imported die wears out just about two 15 in. imported shoes. The average weight of imported shoes used was 300 1-lb., and of imported dies 170 1-lb. The average weights of Co-operative Smelting Works' shoes and dies were 218·9 1-lb., and 128·2 1-lb. respectively.

One set of shoes was treated at the mine before use. They were first heated in a small closed furnace, and then forged under a steam hammer. They forged in about 1 in. in diameter. This set of shoes had no shanks broken, wore very evenly, and gave 104·7 life compared with imported shoes of equal weights.

It has been suggested that liquid pressing would give satisfactory results, but experience of liquid pressed shoes does not compare favourably with forged shoes.

Twenty-five shoes received during November, 1917, are now being tried. To date, 20 of the shanks have broken, with an average life of 16·5 days.

Of 50 shoes received in December and put into commission in January, 22 of the shanks have broken, having an average life of 7·6 days. One of this lot of shoes had a shank broken by the mill shiftsman when trimming the shank with a 4-lb. hammer preparatory to putting it into the the mortar box; another broke whilst being put on. Examination of the fracture shows no signs of blow holes.

The Chairman: I am sure Mr. Jane cannot be accused of gross flattery of those concerned in the manufacture of these shoes and dies; but, of course, this thing is in the experimental stage, and it must be recollected that the imported shoes and dies we have been using in this country have a considerable number of years of experience behind them, and that experience, I have no doubt, was acquired at considerable expense. We are acquiring that experience gradually here and, no doubt, we shall do a great deal better in the future.

FERTILISERS.

By Allan Baguley, B.Sc., F.I.C.

(Printed in Journal, November, 1917.)

DISCUSSION.

Mr. Wm. Taylor Heslop *(Member):* At the present time, when the world's food supplies are of such vital importance, and when South Africa's contribution to them is so handicapped by the cessation of the importation of fertilizers, the author's paper is of exceptional value and interest.

Amongst fertilizers, phosphates always take the first place, and frequently, unfortunately, the only place in farming practice. The author rightly states that phosphates are widely distributed through South Africa although never in any great mass, and usually low in grade. Dr. Caldecott apparently has misinterpreted the trend of the author's statement, when he credits him with "referring to the general poverty in phosphates of South African soil." To find a phosphate deposit capable of development into an industrial proposition for the manufacture of fertilizer, may be very difficult indeed; but on the other hand, there is no doubt that there are large areas of country in which the soil contains quite a good proportion of natural phosphate, which is slowly assimilated as the crops make demands upon it. To realize the difference between the manufacturing proposition and the agricultural;—if we take the farmer's usual dressing of 2 cwt. per acre of fertilizer with 20 phosphoric oxide, and spread it through the first 6 in. of soil, that soil would contain only 0·002 of added phosphoric oxide.

Several years ago I visited the phosphate deposits at Weenen, and noted that they occurred as sparsely distributed boulders in the Ecca shales, *i.e.*, in the characteristic hard shales of the lower portion of the Ecca series. In form, the nodules remind one very much of the clay iron-stone in shale beds of the British carboniferous formations but in colour they are different, blue, green, and naples yellow shades showing according to amount of oxidization.

Since then I have found phosphate nodules scant in quantity, but, in the same Ecca shales, very frequently indeed, and at widely distant points, in Natal and Zululand.

Careful and frequent inquiry amongst farmers has proved to my entire satisfaction that in nearly every district where the Ecca shales are found, the soils derived therefrom are considered as fertile, and very suitable for growing crops. In some of these districts the farmers use no artificial fertilizers,—not because they are unprogressive and lacking in enterprise,—but because they have found, without knowing the reason why, that purchased fertilizers are unnecessary.

My observations are geological,—checked by the experience of practical farmers,—rather than chemical, and I would urge that when a proper soil survey of South Africa is undertaken, as it must be, that it should be based on geological lines rather than geographical, and every soil analysis should carry its record of geological origin. Because of our high altitudes, areas of alluvial soil are small and infrequent, and to a greater extent than in most countries, our soils are sedentary, derived from the geological formation on which they rest, or which is nearly adjacent. In consequence, they may be either comparatively rich in either phosphates, potash, or lime, or exceedingly poor in either one or all three of these minerals, depending on the mineral contents of the parent rock.

The natural inference from the above, is that if from war and economic causes we are unable to take the fertilizer to the soil, then we must take the crops to the soil that is already fertilized by nature.

Unfortunately we at present frequently see large areas of fertile land either totally or very sparsely cultivated, and elsewhere a struggling, enterprising, but inadequately informed farmer trying to cultivate large areas of land that is only adapted for grazing. With the information that would be available from a systematic soil survey, economic conditions would gradually change that. The agriculturist would seek, and pay, higher prices for the land suitable for cropping, and the grazier would move to areas where land prices were more reasonable.

In some districts this process of change and adaptation is already in process. Experience has shown what science has been too slow to teach.

I have remarked on the scarcity of alluvial land in South Africa. Compared with total area this is true, but nevertheless there are many alluvial flats. In areas of scant rainfall, these flats are frequently *brak*, and consequently useless for cultivation. In the areas that are better watered very frequently the alluvial flats are waterlogged swamps and of no use for cultivation because of the excess of vegetable acids, which make the land "sour." Yet these same lands are frequently very rich in humus, and therefore in nitrogen.

Increasing prices of land are daily bringing these areas nearer to the point at which it would be profitable to venture the expense of drainage. Drain pipes are now available of South African manufacture at reasonable prices, and in many cases, money spent on pipes and labour would give as good a return as money spent on artificial fertilizers.

In the matter of fertilizers, if the mountain will not go to Mahomet, it may be profitable for Mahomet to go to the mountain.

With the interest that is now being taken in the development of South African industries and manufactures, there seems to be room for an association of applied science in South Africa. Speaking as a new member, may I, with some diffidence, suggest to the Council that the doors of this Society be kept sufficiently wide open, that it may be able to fill that need.

Mr. John Watson *(Member of Council)*: I would like to explain (partly for Mr. Baguley's benefit) that the writer of this interesting contribution, Mr. Heslop, who is an old acquaintance of mine, is the son of a farmer, and has taken a great interest in farming and horticulture himself, although a colliery manager by profession.

The meeting then terminated.

Correspondence and Contributions.

LOSS OF CYANIDE BY HYDROLYSIS.

I venture to call the attention of members to a paper on this subject by Worley and Browne (*J. Chem. Soc.*, London, 1917, p. 1061), in which the authors, as the result of direct experiments, give data for the percentage of cyanide hydrolysed. The new results are more than twice as high as those which I published three years ago in this *Journal*, as a result of calculation from the dissociation-constant of HCN (this *J.*, August, 1915, p. 9). This discrepancy now awaits explanation.

In my calculations I used $K_{HCN} = 13 \div 10^{10}$ the value given by Jas. Walker for 18° C. (*J. Chem. Soc.*, London, 1900, p. 20). I now find that later American workers give the value as $7 \div 10^{10}$, which when applied to my figures would multiply them by $\sqrt{\frac{13}{7}}$ or 1·36.

The constant found by Worley and Browne should theoretically be equal to the ratio of the water and HCN constants; hence, taking water (at 25° C. or so) as having the constant $12 \div 10^{15}$, their value for the ratio, viz., $4{\cdot}8 \div 10^{5}$ gives by division $2{\cdot}5 \div 10^{10}$ for the corresponding HCN constant, a value much lower even than the American determinations, and quite impossible to reconcile with the direct work on the strength of HCN as an acid, and its electrical conductivity. The weak points in Worley and Browne's work are (1) the poor contact between gas and absorbents, and (2) the assumption that picrates absorb HCN instantaneously and quantitatively.

It is quite possible that the air which was bubbled through contained a trace of CO_2 —and even one part in 20,000 would make a difference—and that absorption of HCN would have been improved by having free NaOH in the indicator reagent.

From the practical point of view I think that the true percentage of hydrolysis in a 0·1 cyanide solution (calculated as KCN) is not more than 3·4 (Worley and Browne give 5·4 , my 1915 paper gives 2·4), but as Worley and Browne propose to make a full investigation of the solution of gold in cyanide, I think they should clear up this discrepancy first.

JAMES MOIR.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

GERMAN WAR-TIME EXPEDIENTS.—"Systematic investigation into the constitution of coal by the 'Kaiser Wilhelm Institute' has resulted in the development of methods of treating it with liquid sulphurous acid at ordinary temperatures to produce a new golden-yellow oil of good body, free from odour, suitable for lubricating and other purposes; the output is 5 kilos. (11 lb.) per metric ton.

Coal Distillation.—Another process developed is the distillation of coal with superheated steam to produce a tar containing entirely different constituents from those given by tar obtained from the usual gas and coke oven furnaces. This new tar contains petroleum-like oils, lubricating oils and paraffin.

A process has also been evolved for producing illuminating oil, similar to paraffin, from the naphthalene obtained in the ordinary dry distillation of coal, as carried out at gasworks and coke ovens. The treatment consists in subjecting the napthalene to high pressure in the presence of a catalysing agent (aluminium chloride).*

(*Note by translator: The use of the latter as a catalyst is well known in petroleum 'cracking' processes.)

Finally, it has been found possible, by treating the coal as a whole with ozone, to convert it into a compound soluble in water, thus opening the way to further chemical treatment, the importance of which cannot be foreseen.

There processes are applicable to bituminous coals (steinkohle), but great progress has also been made in the treatment of lignite coals (braunkohle).

These brown coals are abundant in the central part of Germany, and are largely used in the industrial centres near Bitterfeld and Halle. A few of the largest concerns utilizing the cheap brown coal are Hirsch Kupferwerke, Deutsche Erdöl A.G., Bitterfelder Elektrowerke (H.E.G.), which supplies electrical energy in large quantities to electro-chemical works. The Riebeck Mining Co. have huge plants for the recovery of tar, paraffin and mineral oils on a large scale.

Burning Oil from Worthless Tar.—The Deutsche Erdöl A.G. have succeeded in developing a process of treating brown coal in a producer which, in addition to furnishing power gas (heiz-gas) with recovery of sulphate of ammonia, also makes use of the previously worthless tar by extraction of burning oil for the use of the Navy, lubricating oil, and paraffin, while from the residue is produced coke suitable for the manufacture of carbon electrodes for electro-chemical purposes (*i.e.*, pitch coke).

The extraction of oils from brown coal, which is now being thus carried on in two large plants erected at Rositz and Regis, is of great importance for German war needs. A process recently discovered enables the yield of ozokerite (montanwachs) to be increased from 12% to nearly double that amount, and in addition a quantity of low-grade wax suitable for leather treatment is obtained as a by-product.

The output of gas from the distillation of brown coal has also been improved, and is transmitted over considerable distances for power and lighting purposes, though it is found that under existing conditions it does not pay to transmit gas beyond a 40 kiloms. (25 mile) radius, though this is likely to be improved upon in the near future.

Great progress has also been made in the treatment of mineral oils, more especially those of the paraffin series, to convert them into odourless and tasteless oils suitable for manufacturing edible (*sic*) fat, but little has so far been published regarding these processes.

Substitute Metals.—A new process for the synthetic production of nitrate has been invented by Andiessen and Scheidemandel, and is an improvement on the Birkeland process, which has so far been but little used in Germany owing to the low yield. The new process employs air speeds four times as great as with the Birkeland process, and gives an 80% higher yield.

In the field of metal working much progress has been made in the production of substitute metals, more especially alloys rich in zinc and lead. Aluminium is also being increasingly used, more especially in electrical work, though for the time being overhead lines must depend upon iron and zinc for the material of the conductors, as all the aluminium available is used for the windings, etc., of electrical machinery.

The present high price of metals has resulted in low-grade ores being brought into service which it previously did not pay to work. Copper ores containing as low as 0·7% of Cu. are now being worked, whereas 2·5% was the previous lowest economical limit.†

(†Note by translator: When I visited the Mansfield Copper Works in 1914, I was told that the ore which they worked averaged 3%, the lowest was 2·5%, and the highest 4%.)

Aluminium from Clay.—The attempts to produce aluminium from clay have been crowned with success, and will make Germany independent of foreign supplies of bauxite in the future, which latter is, however, also available in Hungary.

The economical limit for nickel ore content has been reduced from 2·5% to 1·5%. (Note by translator. Canadian ore averages 3·35%, while the New Caledonia ore previously worked by the German works averaged 5·5½% as mined and 6·7% after drying. The Norwegian ores from the Evje mine, which were also worked by Germany to a limited extent, averaged 2·3% nickel and 1·5% in selected ores.)

A process has also been developed for the recovery of metallic nickel and cobalt from the nickel and cobalt rich mine water.

Synthetic Rubber. The synthetic production of indiarubber also appears to have got beyond the laboratory stage, and is now being worked on a commercial scale. The basis of the process is apparently acetylene, which, by the addition of suitable re-agents, is first converted into isoprene; the conversion of the isoprene into rubber is accomplished by the method worked out by Hoffmann, using a suitable catalytic agent.

The production of fibres for the textile industry from stinging nettles (brennessel) has become of great importance, as also the production of paper yarn, and all kinds of material are now being made from this to take the place of cotton and linen goods. After the war paper yarn is likely to remain a serious competitor to jute and hemp.

The rest of the article deals mainly with the artificial production of substitutes for various foods, including albumen, edible fats, etc., as well as mechanical devices for saving labour in agricultural and other industries." Translated from *Neue Zuricher Zeitung.—The Motor*, Sept. 25, 1917, p. 187. (J. E. T.)

DETERMINATION OF CHROMIUM AND VANADIUM IN STEEL.—"The determination of vanadium in presence of iron and chromium has proved rather difficult for routine work. The method herein described has proved satisfactory both for accuracy and speed. Credit for priority for the determination of chromium is due to Phillips* and H. E. Walters.† The determination of vanadium is made after chromium has been oxidized. The vanadium is reduced by ferrous sulphate, the excess of which is oxidized by ammonium persulphate. The vanadium is then oxidized by standard potassium permanganate, from which the percentage of vanadium can readily be calculated. The details are:

Chromium. Two grams of the sample are transferred to a 600 cc. beaker, and 60 cc. sulphuric acid and silver nitrate mixture added. Heat is then applied until all action ceases. If vanadium is present 5 cc. of syrup of phosphoric acid are added. Then 10 cc. of nitric acid (1·20 sp. gr.) are added and the solution is boiled until the fumes are expelled. The contents of the beaker are then diluted to a volume of approximately 300 cc. with boiling water, the solution then heated to boiling, and 10 cc. ammonium persulphate solution added. After the permanganate colour has developed, 1 cc. of concentrated hydrochloric acid is added, and boiling continued until the pink colour disappears and until persulphate is destroyed (about ten minutes). Then the solution is cooled, diluted with water to approximately 400 cc., and the chromium is determined by titration with standard ferrous ammonium sulphate and standard potassium permanganate. Ferrous ammonium sulphate solution is added until chromium is reduced (50 cc. from pipette). Standard potassium permanganate solution is added from a burette until the solution assumes a pink colour which does not fade upon continued stirring. If vanadium is present the pink colour will slowly fade, owing to the slow reoxidation of the vanadium. When the vanadium is completely oxidized, however, a pink colour lasting one minute is obtained, which is the end point.

The per cent. of chromium is obtained by conducting a blank titration on the ferrous ammonium sulphate solution, the same volume of water being used. The difference in cubic centimeters between the volumes of permanganate solution required in the actual determinations represents the volume of permanganate equivalent to the chromium in the steel, and is multiplied by the value of 1 cc. of permanganate solution in terms of chromium.

Vanadium. After the chromium has been determined, 5 cc. of approximately N/20 ferrous ammonium sulphate are added. The contents of the beaker are then stirred thoroughly, after which 10 cc. of ammonium persulphate (20% solution) are added, stirring continually for about one minute. Potassium permanganate (0·03922 N) is then slowly added until a pink end point that remains after one minute's stirring is obtained. Each cubic centimeter used is equivalent to 0·1% vanadium when 2 gm. of the sample are taken for analysis.

A blank determination should be made either on plain steel or on steel containing about the same chromium content as the sample being analyzed. The blank obtained is equivalent to from 0·02% to 0·03% vanadium and is constant. The ferrous ammonium sulphate and ammonium persulphate is sufficient to take care of vanadium as high as 0·60%; for higher vanadium more of the above chemicals should be added.

---

* *Stahl und Eisen*, Vol. XXXII., pp. 1164 to 1167. *Metallurgical and Chemical Engineering*, Vol. XII., No. 5, p. 310.

Solutions for Chromium.—Potassium permanganate, 3·61 gm.; water, 1,000 cc. One cubic centimeter of normal potassium permanganate equals 0·01733 gm. chromium, but potassium permanganate equals 1% of the chromium required to overcome the green colour of chromic sulphate in solution. Therefore 0·0175 times the normality of the permanganate divided by 2 (2-gm. sample taken for analysis) and multiplied by 100 gives the value of 1 cc. of potassium permanganate in terms of chromium.

Sulphuric acid-silver nitrate mixture: Silver nitrate, 5·5 gm.; water 330cc.; sulphuric acid (1 : 1), 670 cc.

Ferrous ammonium sulphate, 19·6 gm.; water, 900 cc.; sulphuric acid (1 : 1), 100 cc.

Solution for Vanadium.—Potassium permanganate, 1·24 gm.; water, 1,000 cc. One cubic centimeter equals 0·1% vanadium when 2 gm. sample are taken for analysis."—H. L. Hamner.—*Metallurgical and Chemical Engineering*, Sept. 1, 1917, p. 206. (J. A. W.)

METALLURGY.

Charcoal Precipitation of Gold.—"Precipitation of gold-bearing cyanide solutions by means of powdered charcoal was adopted at the Yuanmi mine, Yuanmi, W.A., after exhaustive laboratory experiments.

The first stage in the process is the preparation of the charcoal. The best results are obtained from charcoal recovered from the water seal of a down-draught gas-producer in use on the mine, in which local mulga is used as fuel. This charcoal is a waste product. The precipitating agent in charcoal is occluded gas. Quenching while red hot produces the best results, and probably the reason the waste gas-producer charcoal has given the highest recovery of gold, per lb. of charcoal used, is that a large amount of gas is drawn through the char in the hearth of the producer before the particles drop red hot into the water seal. The charcoal is washed free of ash in a cradle arrangement, in a vat of water, and the clean product is placed in a cylindrical mill and crushed, in one-third of its weight of water, with steel balls for about 18 hours. The degree of fineness to which charcoal should be crushed must be determined by comparative precipitation tests; all must pass through a 150 mesh screen (I.M.M. standard). Experiments have shown that wet crushed charcoal has five times the precipitating power of dry crushed charcoal, and the finer particles have a greater efficiency than the coarser particles, even of 150 mesh product.

The charcoal sludge is fed into three Moore-Edmands precipitation units by means of a centrifugal pump. The precipitation units are equipped with filter frames of the vacuum type, spaced 4 in. centres; the agitation of cyanide solution, which gravitates to the units, and of the charcoal sludge is effected by propellers attached to a spindle which revolves in the lower portion of the precipitation unit at 190 revolutions per minute. The units are charged with about 300 lb. of charcoal sludge (dry weight). Before cake forming is started the pulp is thoroughly agitated by the propellers. To prevent channelling, while the process is going on, the vacuum is periodically shut off, the cakes dropped, and the sludge thoroughly agitated.

The capacity of charcoal to precipitate gold soon decreases. The process is therefore carried on in two or more stages. The cyanide solution drawn off from the first unit is delivered by the vacuum pump to a storage vat, whence it flows to the second precipitation unit, and so on to a third unit if necessary. When the charcoal in the first unit has lost its power for rapid precipitation the charcoal in the second unit is still little impaired. The flow of solutions is then reversed, and the maximum precipitating power from a given quantity of charcoal obtained. The following is a typical day's run:—

Head value of solution 20s. 3d. per ton (2,000 lb.)
Tail value of solution from 1st unit 6s. 7d. = 67·5% precipitation.
Tail value of solution from 2nd unit = 9·5d. = 96·1% precipitation.
Tail value of solution from 3rd unit Trace = 99·9% precipitation.

The amount of gold precipitated per ton (2,000 lb.) of mulga charcoal averages about 770 oz.

There is never any trouble in passing all the solutions from the plant through the precipitating units; their capacity has not been definitely determined, but exceeds 300 tons daily.

When the precipitating power of the charge in the units is nearing exhaustion, as indicated by assay, the plant is cleaned up. A charge lasts from 10 to 20 days, according to the amount of gold contained in the solutions passing through the units. Precipitation is not directly proportional to value of solutions, but rich solutions more speedily exhaust the power to precipitate rapidly. To clean up, the vacuum is released, the cakes dropped and emulsified by the propellers. The sludge is run into a concrete vat beneath the units and the moisture removed in a clean-up press of the ordinary type. While damp enough still to be adhesive the precipitate is placed in lumps in braziers constructed of strong wire screening, ¼ in. aperture, and burned to an ash, a process which takes about a day and a-half and is carried out in a lock fast chamber. There is practically no loss by dusting or volatilisation. The ash which remains to be smelted amounts to about one-third of the weight of charcoal fed into the units.

There is no trouble in smelting the ash with the usual fluxes, and the wear on crucibles is much less than from zinc precipitate. The smelted gold, without refining, is remarkably pure. From clay-lined pots gold worth £4 2s. 6d. per oz. is obtained, and from graphite pots the gold is worth about £4 1s. per oz. Using zinc as a precipitant the bullion produced from the same ore after considerable refining, could only be brought up to from £3 8s. to £3 12s. per oz. The finer gold obtained from charcoal effects a considerable saving in bank and mint charges.

Prior to the use of charcoal as a precipitant this section of the treatment plant was a constant source of anxiety. The trouble in precipitation arises from the presence of antimony and arsenic in the ore. With the ordinary zinc shaving as a precipitant, tail solutions from the boxes were most erratic, and at times alarmingly high. Experiments indicated that better work would be obtained from zinc used as a powder, and to carry out the work cheaply and effectively the mine metallurgists, Messrs. K. Byron Moore and H. R. Edmands, designed the precipitation units now in use. The use of charcoal was evolved by the same gentlemen as a war time economy. The process has been in operation for about a year, and has proved a complete success metallurgically and financially. At the present price of zinc the saving effected is about 1 per ton of ore treated. A further saving has been brought about by the lowering of the final residual value of the ore, as box tail solutions from zinc boxes, part of which are lost, could never be reduced to the figure now obtained by charcoal precipitation.

Notes by R. C. Wilson

There is one other advantage about the process which is worth mentioning, and that is the whole of the charcoal in a precipitation unit is burnt and any shortage of gold can be immediately detected, whereas when a zinc box is cleaned up portion of the zinc carrying gold is put back into the box, and as it is not an easy matter to determine just how much gold has been put back a shortage in gold is not readily detected. The clean up is much simpler and cheaper than the clean up of an ordinary zinc box. This will be clear from the following comparison :—

Clean up of Zinc Box. 1. Take out all zinc from the boxes, clean out boxes, and put back portion of the zinc and send remainder to acid tubs. 2. Add sulphuric acid till all zinc attacked. 3. Syphon off acid ; wash and dry zinc slime. 4. Roast slime. 5. Flux and smelt.

Clean up of Charcoal Dust. 1. Run out charcoal sludge and dry sufficiently to make into balls. 2. Burn charcoal balls (these burn quite readily). 3. Add flux to ash and smelt.

The advantages of charcoal dust precipitation may be summarised as follows :—

Charcoal costs little or nothing ; no acid is required ; purer gold is obtained ; any shortage in gold is readily detected."—H. G. WALTON.—*Chemical Engineering and Mining Review*, Nov. 5, 1917, p. 48. (H. A. W.)

MINING.

MINING PROBLEMS ON THE RAND *(Concluded)*.—Transport of materials underground on the Rand is usually effected for short distances by hand tramming or trucking. Longer hauls are commonly accomplished by endless ropes, a system that has great vogue in Africa, but electric and petrol locomotives are also in regular use, while experiments are being made with storage-battery locomotives. The advantage in cost seems to be with the rope, where the roads are sufficiently straight to allow its use. Thus at the Geduld rope-haulage costs 9·8d. per ton and at the Modder Deep, with a larger tonnage, this comes down to 3·89d. Electric haulage at the Geduld costs 12·057d. per ton but the track is of 18-in. gauge, and crooked, grades are at 1%, and for fear of accidents to workmen the voltage is held down to 240.

It is difficult to get exact comparisons, but the following figures from the Crown Mines are suggestive of the advantage of a system of storage-battery motors for gathering, with delivery to main haulages operated by ropes or electric locomotives.

	Tons	Cost per ton. Pence
Electric locomotive	124,535	2·7
Petrol locomotive	30,911	4·7
Endless rope	25,037	1·9
Storage-battery	13,875	1·4

These figures are suggestive only, as they do not take into account the effects of varying distances and conditions. In discussing the transport of materials with especial reference to work above-ground, C. O. Schmitt* has given much interesting detail regarding rope-haulage and pointed out its limitations.

Having gone to the Rand full of the current idea that it is the field pre-eminently of large-scale mining, it was somewhat of a shock to find the small amount of ore hoisted per day per shaft. It has already been shown that there are only five companies that treat more than 75,000 tons per month and all of these pull from more than one shaft. Nearly half the companies are content with less than 50,000 tons per month and a manager who delivers 60,000 tons per month through two shafts and at the same time handles men and supplies, considers that his record is exceptionally good. This is the more surprising in that the mines are generally dry, they require little timber, and the larger part of the men are underground but one shift. It is true that depths are considerable, but in hoisting it is the starting and stopping that consumes time. Increase in depth does not increase proportionately the time needed to bring a skip to the surface. By way of comparison it may be mentioned that collieries in Great Britain are equipped to hoist 5,000 to 6,000 tons in two shafts from a depth of 2,400 ft. Collieries in Illinois hoist 800 tons per hour from a depth of 700 ft., and it is to be remembered that in colliery practice self-dumping skips cannot be used. The Inspiration Copper Co. in Arizona, using twin shafts, is hoisting 10,000 to 11,000 tons per day of 14 hours from a depth of 630 ft. In this case the hoisting is done automatically by means of 580 h.p. direct-current motors, one for each shaft. The engines, having been started, continue to hoist automatically-filled, self-dumping skips until stopped, or until some one of the numerous self-acting safety-mechanisms comes into play. To return to gold mining, it may be mentioned that the new hoisting arrangements at Treadwell in Alaska are designed to handle 5,000 tons per day from a depth of 3,000 ft. It is not intended to suggest that conditions are the same as on the Rand, but, having in view the great expense of shaft-sinking, too little use is made of a shaft when it is once down. Probably the most striking contrast with Rand hoisting practice is afforded by the Kimberley diamond mines. At the Du Toits Pan 7,021 tons was hoisted from 750 ft. in 7 hours 35 minutes, and at another time 8,873 tons in 10 hours 2 minutes. At the Wesselton, from 980 ft., 8,286 tons was hoisted in 10 hours 35 minutes. While methods used elsewhere can hardly be transferred *en bloc* to the Rand, it does seem to be a fair question why Rand engineers do not so change their arrangements underground and at the surface as to permit full advantage to be taken of existing plant and shafts. It is true that most managers start with the mistake already made but there are mines still to be opened and it is a question whether profits would not accrue if some existing shaft. were closed. The low rate of hoisting is not due to poor winding-engines. In the main these are excellent and thoroughly in keeping with the high standard of construction set by the mechanical engineers, but they are not used to capacity. The trouble is with the arrangement underground for gathering the ore and bringing it to the shaft and for this the principal responsibility rests on the men who direct the policy of the mines.

---

* "Rand Metallurgical Practice," Vol. 2 1912.

In consequence of using public money in Rand mining, it has become a settled policy to give the industry the greatest possible appearance of stability and regularity. One result is the excellent plan of developing far ahead, so as to create a large reserve of ore. Another is the insistence on uniform monthly returns. It seems to be thought that if the returns went up and down the shareholders would become unduly anxious and that an unhealthy amount of speculation would be induced. The responsible managers also fear that, however honestly they might act, the public would always believe that the grade was being manipulated with a view to the market for shares and that they were making profits out of prior knowledge. There is something in this. It is, however, by no means certain that the shareholders are as concerned about monthly returns as is thought or that, granted that they have become so, it is not largely the result of education. What the shareholders want is dividends and, unfortunately, these have been by no means as regular as the monthly returns of output. However, in practice, the greatest pains are taken to mine to the average of the ore. Formerly this was less closely done and a part only of the gold extracted was declared, the rest being placed in a secret reserve. Then it became the fashion to publish the reserve, after which there was nothing for it but to discard the practice. So that was done—nominally. Actually what happened was that the visible reserve became invisible. It retreated to the amalgam-safes, the zinc-boxes, and the stopes; it is there to-day and is used regularly to equalise returns. The Rand banket is by no means of uniform value. The grade varies from day to day as in other gold mines. At one mine where I examined the assay-sheets, the ore sent to the mill varied from 4 dwt. to 16 dwt. per ton. In two days it jumped from 7 dwt. to 16 dwt., and yet the manager must so arrange matters that each month checks with its predecessors at about 6·50 dwt., which is the established grade of the mine. In another property, treating ore averaging a little above 6·5 dwt., there are areas sufficiently large to supply the mill for months at an average of over 30 dwt.

The policy of working to an average grade month by month, necessarily entails keeping open a large number of stopes. It also requires frequent shifting of men and a constant re-arrangement of work underground; in the ore-house it leads to the difficulties of which mention has already been made. Perhaps it is worth the price, but it would be interesting to know exactly what the extra cost is. Approximate estimates made by men on the ground vary from 6d. to 12d. per ton. It would seem entirely possible that the cost is even larger if all items be taken with account. There is also the loss of interest due to rich ore remaining underground. There would be many advantages in adopting the policy of mining the ore as it came, so long as it was above cost in grade. For one thing, the great areas of open ground, left so that it is possible to go back and re-work stopes, are not only a potential danger from possible squeezes, but an actual one in that they interfere with effective ventilation. They are full of dust, which is stirred up by blasting. If an area could be promptly and fully worked, and then filled or closed off, conditions underground could be greatly improved.

As regards ventilation in general, the Rand mines have still a long way to go. A saturated atmosphere and temperatures up to 85° F. are destructive of efficiency, to say nothing of health, among the workers, and there are places where such conditions obtain. The mines are just beginning to be systematically ventilated but the companies have not as yet taken ventilation needs into intimate account in laying out underground work. They are about in the stage that the collieries were when they tried to work on a single-entry system, a plan long since abandoned. Having in mind the greater cost of driving in quartzite than in coal, a complete system of double entries seems out of the question, but stoppings, doors, and brattices are not, and with the wide double-track main haulageways it might be possible to do something effective by building a thin wall of brick between the two tracks as has been suggested by W. G. Holford.* If this were done on the main haulage advancing down the dip, it would be possible to carry fresh air direct to the lowest part of the mine in quantity. This, by decreasing the dust and reducing the temperature, would greatly improve working conditions. For the main laterals the use of a pilot-drift on the ore, connected at intervals with a haulage-drift in the foot-wall, would also carry the air. It is important in all this work to realise that large quantities of air are needed and that it must be carefully directed to the working-places if best results are to follow. Naturally any system of work that reduces the amount of ground open at one time will reduce the ventilation expense. It must be a matter of much careful consideration where to draw the line between the desirable position of having large reserves of varied grade, and of operating with the minimum working cost.

Over a period of years it is impossible to mine faster than ore is developed, and to give reasonable security for investment in plant it is customary to keep in reserve about two years ore-supply, which means loss of interest on the development-cost of that ore throughout the life of the mine to within two years of its abandonment. In the Far East mines, and also probably the deep mines of the Central Rand, the managers feel that development is being pushed at the maximum speed; every face that can be opened is kept going as fast as it can. Where this is true, the critical element is undoubtedly the fact that there is less ore per claim in the deeper ground and that where the dip is flat the amount of driving necessary to develop a ton of ore is greater. It is also much more expensive and difficult to drive at great depth because of the cumulative effect of minor hindrances. While the rate of stoping is slow on the Rand, back of that is the slow rate of development. This can only be improved by changing methods, harder driving, and other alterations which come back to modified regulations. Unless the importance of this be recognised and persistent efforts be made to effect real changes, the cost of mining on the Rand is not likely to be greatly lowered. Concentration in mining must be preceded by extensive development. In this direction the managers realise the need, but between owner, miner, and Government they find progress all but blocked.

---

* *Trans. Inst. M. & M.*, Vol. XXIV., p. 278.

In any event, and however far it may prove desirable to push concentration of mining, it is advisable to pay more attention to the main haulages and the shaft stations so as to get greater returns from the heavy investment in shafts. How large this is and what proportion it forms of the total expenditure is indicated by figures from a number of Far East Rand mines at the end of 1915:

	Shaft-sinking and equipment.	Total capital expenditure
Brakpan	£407,976	£1,184,975
Geduld	193,391	1,100,000
Springs	157,197	746,000
Government Areas	728,826	1,569,000
Modder B.	131,213	855,159
Modder Deep	131,523	672,000

This problem of possible concentration of work is one that warrants thorough study. On the Rand the ratio of white to coloured labour is high compared with mines elsewhere, and the contract system of directing stoping is proving unduly expensive. If concentration be feasible it is possible that labour difficulties may be lessened by substituting a large measure of direct company supervision for part at least of the contractors, and it is not impossible that the proportion of white to black labour can be made smaller.

In these and many other problems there is a conflict of interest between the engineer striving for technical success and the business manager who must keep in mind immediate as well as ultimate returns. It must also be frankly recognised that a change involves risk to the engineer as well as to the financier. If, for example, it be decided to break the ore as it comes rather than to mine always to grade, the inherent probability of a combination of circumstances leaving the mine with low grade ore when returns are most needed, must not be overlooked. More money will be made for the shareholders in the end, provided the mine is adequately financed but if it be dependent on the share-market for capital for additional equipment the shareholders might lose as a result of a really sound policy having been followed; in any event, both engineer and manager would need to expect periods of criticism. There is a real conflict here between the claims of technology and financial policy.

It would be presumptuous in a visitor to suggest where in any case the line is best drawn. That is a matter only to be decided after much study and with intimate knowledge of the particular property involved. I would, however, urge the importance of these problems and suggest the advisability of fuller public discussion of them. The opening of the deep mines of the Rand, and particularly those in the central part of the Far East Rand, such as the Brakpan, is a real achievement in mining and this discussion will, I hope, be read more as a frank friendly raising of questions than as a criticism of current practice."—H. Foster Bain. *Mining and Scientific Press*, June 2, 1917, p. 763. (H. R. A.)

MISCELLANEOUS

Direct Recovery of Ammonia.—*Improving Results.*—There can be little question that as regards ammonia recovery gasworks will in the future abandon their present methods in favour of the more modern direct or semi-direct systems. Ammonia is one of those products which is likely to be affected to no little extent by the scientific methods now perfected for its production by synthesis; accordingly, as competition will have to be met, every effort will be necessary in order to curtail the present cost of manufacture.

In the ordinary way, the ammonia derived from the distillation of coal is wholly recovered in the form of ammoniacal liquor, the liquor being subsequently worked up into sulphate of ammonia in a distinct plant, which practically constitutes an auxiliary chemical works. Continental chemists have endeavoured to avoid the necessity for providing a separate unit for working up the ammonia into commercial form by introducing processes which recover the by-product in the ordinary course of gas-making. The most scientific, but as yet somewhat impracticable, methods are those in which the acid impurity, sulphuretted hydrogen, is caused to combine with the ammonia, thus avoiding the necessity of purchasing sulphuric acid. Such processes are generally characterized as 'direct.' On the other hand, the 'semi-direct' methods, though they entail the use of sulphuric acid, have a good deal in their favour in respect of reducing such items as labour and capital expenses, and it is to these processes that the major share of attention has been given in this country. In fact, the importance of the method is such that the Chief Government Inspector under the Alkali Acts (Mr W. S. Curphey) has during the past two years given the matter his particular attention, and it may be recalled that in his 1915 report he gave prominence to the difficulties with which these new plants are beset, chiefly in the way of trouble with the dry purifiers and loss of ammonia.

During 1915 the process was conducted at 21 gas works in the United Kingdom; and, with few exceptions, it was shown that so poor was the recovery of ammonia in the form of sulphate that the average quantity obtained per ton of coal was only 15 lb. to 20 lb., against a normal yield of 26 lb., obtained with the older method. The loss was chiefly attributable to the fact that trouble was consistently occurring with the dry purifiers, and in order to remedy the disorganization it was customary to by-pass a large proportion of the crude gas containing ammonia, this portion of the ammonia being lost. During 1916 investigation with regard to this purifier derangement was carried considerably further, and Mr Curphey has collected and tabulated some instructive information with regard to the most favourable conditions which should be allowed to prevail. In particular it was found that disorganization was most common when the oxide material in the dry purification vessels was highly charged with moisture, in which condition it was apt to become 'soured.'

Condition of the Oxide.—Various suggestions were made to effect the desired improvement, such as careful regulation of the moisture content of the oxide, the use of a washer to control the ammonia content of the gas entering the purifiers, the use of steam pipes below the bottom grids in order to maintain the working temperature of the boxes during the winter months, protection of the boxes from rain and cutting winds, and the use of control thermometers in the system. The past year afforded an opportunity for testing the value of these suggestions, and substantial advance has been made towards a more scientific control of plant. It is particularly gratifying to note that the recovery figure for sulphate of ammonia shows improvement, and periods of disorganization can now be anticipated with some degree of certainty, even if they cannot always be prevented owing to causes beyond the power of those in charge to control. The elucidation of the problem, however, is by no means complete, and further work remains to be done before the effect of the varying factors is satisfactorily determined.

Investigation during the past year was especially directed towards the attainment of two ends—namely (1) to determine the conditions best suited to maintain the efficiency of the oxide purifiers at a maximum, and (2) to determine the cause of the relatively low yield of ammonia in the semi-direct process, also to devise means for the prevention of loss. The extent of hydration of the oxide of iron is a factor of considerable importance, and one upon which there is a good deal of divergence of opinion among gas engineers. For instance, the general tendency on gasworks is to prepare the material in such a manner that it contains, in addition to its water of combination, about 30% of moisture. This practice, however, according to Mr. Curphey, deserves attention, for experience of the working of the semi-direct process had led to the opinion that the use of an oxide with low moisture content is preferable, and it is essential to avoid the use of fresh oxide highly charged with moisture. Periods of disorganization were most frequent with a very moist material, and less frequent when the oxide was moderately dry.

There are many reasons which account for this fact, for when the semi-direct process is operated, purifying conditions are very different from those which normally prevail. Thus, crude gas in the direct process leaves the acid saturator at a relatively high temperature (often exceeding 90° F.), and it is subjected to very imperfect cooling before entering the purifiers. On the other hand, in cases where cooling is more effective the condensed moisture removes the greater portion of the residual ammonia, the presence of which is essential for the desired reaction in the boxes. Everything, in fact, tends towards the deposition of water in the purifiers; thus the correct policy would undoubtedly appear to be that of ensuring the use of a relatively dry oxide. The case of each works, however, needs separate consideration.

Temperature Conditions.—In the 1915 report of the Chief Inspector, the conclusion was reached that a working temperature of from 10° to 80° F., should be suitable under ideal conditions of work. During 1916, however, a complete set of temperature observations was made at two works operating the semi-direct process, and the results indicate that, under the special conditions prevailing, temperatures much exceeding the above limits are consistent with efficiency. Purifiers generally would undoubtedly be under far better control, more especially during the winter months, were the boxes better protected from the weather, and maintained at a steady temperature, controlled, if need be, by means of steam pipes. In this connection the adoption of a rotation system would appear to offer advantages, since the cyclic movement of the boxes brings them successively into the reaction zone, thus helping to maintain an even temperature throughout the system, and minimising the local deposition of moisture, which is a great source of trouble during the cold weather. Where it has been adopted, the backward rotation system has been found effective in combination with the semi-direct process.

The helpful effect of ammonia in oxide purification has long been recognised, but the part the ammonia plays still remains obscure. Experience confirms the view that while purifiers will undoubtedly work well under conditions which result in the formation of soluble salts of iron (ferrous sulphate), the activity of the oxide is distinctly higher when sufficient ammonia is present in the crude coal-gas to maintain the oxide in a neutral or slightly alkaline condition, and in some works the life of the oxide has been markedly extended by the supply of a controlled amount of ammonia to the boxes. During 1916 Mr. Curphey directed special attention towards determining the minimum amount of ammonia necessary to maintain the purifiers at maximum efficiency. Results are difficult to interpret, but there is reason to believe that the amount of ammonia necessary for maintaining the oxide in a neutral condition bears a direct relationship to the quantity of ferrous sulphate formed, and that the formation of ferrous sulphate is favoured by excessive moisture and possibly by too low a temperature. The amount of ferrous sulphate present at any given moment in the mass appears to be small, probably under 1%, but in relation to the actual reacting weights of sulphuretted hydrogen and ferric hydrate the amount cannot be regarded as negligible. It has been shown that during any given period of working a portion only of the oxide of iron in a purifier takes part in the reaction. It is the surface layer that is active, rather than the denser substratum, and if ferrous sulphate be formed on the surface its conversion into ferrous hydrate or sulphate may have a profound effect upon the catalytic activity of the material.

Efficiency of Recovery.—The low ammonia recovery figures associated with the semi-direct processes during 1915 were followed by an inquiry during 1916, when certain points in the working responsible for this loss were noted. It is necessary to remember that even in the direct and the semi-direct processes a certain amount of ammoniacal liquor has to be dealt with, this liquor known as 'virgin liquor' being formed in the hydraulic mains and condensers of the coal-gas plant. The virgin liquor is usually distilled with lime so as to evolve the ammonia in the gaseous form and, afterwards this ammonia is mixed with the crude gas just prior to the acid saturator. Of the total ammonia passing through the saturator, it is shown that at least 50%, and probably 60%, is supplied by the virgin liquor—an amount far in excess of that previously supposed. Examination of the effluent liquor from the stills indicated, moreover, that in this direction a very serious loss of ammonia was taking place at some works, and that as this ammonia was chiefly present in the 'fixed' form an insufficiency of lime was responsible. At one works ammonia equivalent to no less than 5½ lb. of sulphate per ton of coal carbonized was being run to waste, at a second works the ammonia lost in this way was equivalent to 5 lb. of sulphate, and at a third the loss was 3 lb.

In spite of the attention that has been paid to the semi-direct plants in order to prevent loss of ammonia the yield of sulphate, though improved, is still relatively low. It may be, however, that although the absolute figure for recovery is undoubtedly disappointing, the ammonia originally in the crude gas is low, so that the percentage recovery figure may prove better than is generally supposed.

The elucidation of the problem as to how much ammonia is required in the oxide purifiers will be awaited with interest among gas engineers. At the moment, in those instances where the old fashioned type of sulphate plant is in use, the effective operation of the purifiers appears to be secured by the addition of half a grain of ammonia per 100 cub. ft. of gas. With the direct process 2 gr. to 3 gr. of ammonia per 100 cub. ft. of gas seem to be ample in the summer months, but it is recorded that hitherto in the winter time as much as 15 gr. to 20 gr. have been required. The relation which such a quantity bears to the ammonia recovered per ton of coal can be appreciated when it is remembered that 13 gr. of ammonia per 100 cub. ft. of gas correspond to 1 lb. of sulphate of ammonia per ton of coal." *Times Engineering Supplement*, Sept. 28, 1917. (H. R. A.)

New Book.

INTRODUCTION TO THE RARER ELEMENTS. By PHILIP E. BROWNING, Ph.D., Assistant Professor of Chemistry, Kent Chemical Laboratory, Yale University. Fourth edition, thoroughly revised. New York: John Wiley and Son, Inc. London: Chapman and Hall, Limited, 1917.

This book consists of 250 pages packed with information regarding some sixty-five rare elements, mostly metals, many of them being discoveries of the chemists in recent years, and some thirty being now used in the arts. The elements are treated in eleven groups according to their chemical affinities. Each group is accorded a chapter to itself, the groups being—(i.) the alkalies (lithium, rubidium, cesium); (ii.) beryllium; (iii.) the radioactive elements (uranium, radium, etc.); (iv.) the rare earths (yttrium, cerium, thorium, zirconium, etc.); (v.) gallium, indium, thallium; (vi.) titanium, germanium; (vii.) vanadium, niobium, tantalum; (viii.) molybdenum, tungsten, uranium; (ix.) selenium, tellurium; (x.) the platinum metals; (xi.) the rare gases of the atmosphere. Each chapter contains a list of minerals in which the elements dealt with are found, with their chemical compositions, method of extraction from its source in nature, properties, known chemical compounds, and their properties. A table of the rare earth minerals shows a list of some 180 rare minerals. Copious references are made to chemical papers dealing with original work on the elements and their compounds. A separate chapter deals with the technical application of the commercially important elements and their compounds, with numerous references to technical journals, where more detailed information can be acquired. Two other chapters describe the method of detection of the various elements by qualitative and spectrum analysis, giving tables for the separation of the various members of a group by chemical reagents and charts of spectral lines. The book is written primarily for chemists, but should be useful also to the mineralogist likely to be called upon to give advice as to the possibility of finding markets for some of the rarer minerals." *Queensland Government Journal*, Nov. 15, 1917, p. 785. (H. A. W.)

Abstracts of Patent Applications.

3.17. Edgar B. Symons. Improvements in crushing machines. 2.1.17.

This application refers to a vertical spindle type of the Symons' disc crusher.

The application, which comprises twenty-five claims, refers to nearly every detail of the machine in combination with a sliding and rotating disc.

33.17. Alexander Purser (1), George Daniel Hook (2). An improved valve for compressed air and the like. 3.2.17.

This application is for a retaining valve, which by means of an adjusting screw, is converted into a valve automatically operated by fluid or air pressure in such a manner that the valve controls the passage of the fluid, so that a full flow cannot pass through until the pressure upon the discharge side has risen to, approximately, that upon the retaining side of the valve, when the valve is further opened by means of a spring as described.

375.17. Daniel Diver. Improvements in amalgamator and separator. 26.6.17.

This application is for an amalgamating apparatus consisting of a panning arrangement operated like a batea without the grinding balls. Contact with the mercury is insured through the medium of a fluid jet, adapted to impart different velocities to the metal particles in such a manner that the lighter matter rebounds from the surface of the mercury.

492.17. Walter Reginald Hume. An improved moulding machine and moulds for manufacturing cement and cement pipes. 20.8.17.

This application refers to an improved moulding machine and moulds for manufacturing cement and concrete pipes a series of parallel axles having frictional drive wheels thereon, said wheels not being in contact with each other, a toothed wheel or a belt being mounted upon one of the axles whereby power is received from a gear axle for the transmission of rotary motion to the adjacent drive wheels, and cylinders having flanged runners at either end which fit upon adjacent frictional drive wheels and receive and impart rotary motion therefrom and thereto.

There are six other claims referring to details with regard to the manner in which the moulds used in this process of manufacture are more particularly described.

Changes of Address

BEATTY, G. H., *To* Johannesburg: P.O. Box 2, Randfontein.
GALBRAITH, N. M., *to* Liddle Street, Bertrams, Johannesburg.
KENNEY, H. S., *To* Johannesburg: P.O. Dersley.
PEARCE, J. W., *To* Johannesburg: Belingwe, S. Rhodesia.
THURLOW, J. R., *To* Benoni: P.O. Box 1056, Johannesburg.
VEASEY, J. H., *To* Benoni: Randfontein Central G.M. Co., P.O. Millsite.

APR 15 1920
UNIVERSITY OF T

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII. MARCH 1918. No. 9.

Proceedings
AT
Ordinary General Meeting, March 16, 1918.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 16th March, 1918 Mr. G. Hildick-Smith (President) in the chair. There were also present:—

35 Members: Messrs. H. A. White, J. Chilton, J. Gray, H. C. Hilton, C. E. Hutton, C. Toombs, John Watson, A. McA. Johnston, Dr. J. Moir, J. E. Thomas (Members of Council), R. W. Bennett, C. B. Brodigan, J. M. Campbell, Palmer Carter, J. M. Dixon, P. Friedman, N. M. Galbreath, C. J. Gray, Dr. L. G. Irvine, A. H. Krynauw, C. A. Meiklejohn, E. C. J. Meyer, W. C. Mossop, S. Newton, E. A. Osterloh, F. G. A. Roberts, C. Rowe, E. R. Schoch, J. A. Taylor, J. M. Thorburn, J. Thorlund, H. Warren, G. A. Watermeyer, R. H. Wennacott.

11 Associates: Messrs. E. Macleod Elliott, O. A. Gerber, J. Gibson, W. Human, J. Innes, J. S. Moir, H. Rusden, W. Russell, H. Ward, J. Whitehouse, J. A. Woodburn.

80 Visitors, including Lt.-Col. Macaulay, S.A.M.C., Major J. Pratt Johnson, S.A.M.C., and representatives of the S.A. Mine Workers' Union.

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 16th February, 1918, as recorded in the February *Journal*, were confirmed.

ELECTION OF NEW MEMBERS.

The President: I wish to announce that the Council has admitted two Associates since the last meeting:—

Bulman, Lieut. Gerald, S.A.S.C.M.T., Nairobi, B.E.A. Mine Sampler

Lockhart, Sergt. T. L., 143, Princes St, Edinburgh.

HONOURS FOR MEMBERS.

The President: Before going on to the business on the agenda, I think the Society is to be congratulated on having had two of its members, Mr. Evelyn Ashley Wallers, President of the Chamber of Mines and Hon. Vice-President of this Society, and Mr. Douglas Christopherson appointed Commanders of the Most Excellent Order of the British Empire, and two of them appointed Members of that Order, Mr. E. G. Izod, and our Secretary, Mr. Fred Rowland. On your behalf, I wish to congratulate those gentlemen and, without making any comparisons, I would especially congratulate our Secretary, Mr. Fred Rowland, because most of us know exactly how much work he has done to have deserved this honour. I am sure we all congratulate him very much, and the Society, at the same time, takes a little of the credit, because, some years ago, we agreed to allow Mr. Rowland to do this work for the Red Cross Society in addition to the work that he was doing for us.

MERCURY.[*]

Mr. E. M. Weston *(Member of Council):* Dr. Caldecott's note reminds me that some years ago in a discussion on a milling paper[†] I expressed very decided and unorthodox views on the use of mercury in gold mills. True to their characteristic conservatism, my arguments were never answered, and the facts supporting them ignored, by Rand metallurgists.

My argument, briefly, was: First, no particle of gold is worth amalgamating that has not mass enough to sink in water and come in contact with the plate. Any particles of smaller size are much more easily recovered in the cyanide plant. The idea that one is saving money by increasing the percentage recovery by amalgamation (5% or so) is a relic of barbarism. It is the idea of the ancient mill man with his inexact methods. "Catch the gold as soon as possible at any cost." Second, if gold (sp. gr. about 19) will sink at all, it can be rapidly and easily concentrated and separated for final treatment with a minimum of mercury in the barrel.

---

[*] See this *Journal*, Vol. XVIII., Jan. 1918, pp. 162-163; *ibid* Feb 1918, pp. 173-180.

[†] See this *Journal*, Vol. XVI., Sept 1915, pp. 55-57.

I suggested means for doing this, and gave instances where in milling gold ores, mills not using mercury made as good a recovery as others using it. Several years later metallurgists now start experimenting with one thing I recommended—canvas; but unless they use the arrangement I showed, they will, I think, find the surface too small. No one has apparently tried the hydraulic arrangement I suggested.

Mr. H. Ward *(Associate)*: The mercury question opens up a very important discussion on the recovery of gold, especially to those who realise the importance of recovering as much gold as possible at the mill. I have yet to be convinced that more than 85% of the gold passing to cyanide works is recovered by that process, in spite of assertions to the contrary. I would appeal to millmen to always keep in view the importance of their percentage of the total "recovery," as being of the greatest importance, especially so during this critical period, and its effect on profit, as will be seen by the following sample calculation:—

On a basis of 40,000 tons milled at 6·50 dwt. = 13,000 oz. screen content.

Residue:

Possible at 70% mill, 10,000 tons milled at 0·26 residue = 520 oz.

More probable at 50% mill, 40,000 tons milled at 0·35 residue = 700 oz.

Difference: 180 oz., value £750.

Or at 70% of screen content recovered by amalgamation equals 9,100 oz. from mill, leaving 3,900 oz. passing to cyanide works, of which only 85% is recovered, making a recovery of 9,100 oz. + 3,315 oz., total 12,415 oz., or 95·5% of extraction of screen content.

Against 50% of screen content recovered by amalgamation = 6,500 oz. from mill, leaving 6,500 oz. passing to cyanide works, of which only 85% is recovered, making a recovery of 6,500 oz. + 5,525 oz., total 12,025 oz., or 92·5% extraction of screen content,

showing a difference between the two methods of 390 oz. fine gold, value £1,650, surely a margin worth serious consideration.

Mercury loss with the higher percentage of extraction by amalgamation should not exceed 0·10 oz. per ton milled with a plate area of from 1·25 to 1·5 sq. ft. per ton crushed. My experience is that a large plate area is necessary when a percentage of from 68% to 72% of the total gold recovered can be recovered by amalgamation.

Some plants seem to be arranged to pass as much gold as possible to the cyanide works. This, in my opinion, is bad practice. All pulp leaving mill and tube mills should pass over an amalgamated surface of sufficient area, the higher recovery being of considerable help and guidance to the management as to daily grade of ore to mill, instead of having to take "pots-luck" at the month end. Another practice which may have a direct effect on mercury loss is the placing of theoretical men in charge of milling operations, who, having no practical experience, have simply to leave the management to others, and whose interests are not affected if the mercury loss is 0·10 oz. or 0·20 oz. per ton.

Loss of mercury through steaming plates should be a thing of the past, as this is absolutely unnecessary. Proper dressing and daily scrapes will prevent any accumulation, except what can be recovered by hard scraping and scouring at end of month. I can call to mind plates which had not been steamed for three years. After that period only 7 oz. of gold was available per plate of 9ft. 6in. × 5 ft. This is not in accordance with the theory advanced as to the locking up of gold on plates. These plates had recovered 70% of the total gold recovered during this period.

Assuming that mercury will become more difficult to obtain, I am of opinion that corduroy is the best substitute, this opinion being arrived at by practical experience.

THE ESTIMATION OF INJURIOUS DUST IN MINE AIR BY THE KOTZE KONIMETER

By John Innes (Associate)

The recognition by the Ferreira Deep, Limited, of the advantages which the Konimeter possessed over other methods of dust sampling, led to its introduction on that mine as early as August, 1917. We were thus enabled to carry out tests before its use had become general, and it seemed desirable, as a result of these experiments, to place our experience on record so that initial difficulties might be removed for others who intended to adopt this system of sampling.

The pamphlets on the Konimeter issued some months ago by the Miners' Phthisis Prevention Committee largely nullified the value of such a paper, and the idea might have been abandoned but for the fact that the dust sampling question assumed a different aspect from what was expected. Opposition to the new method appeared in many quarters, so we were encouraged to continue our investigations until the arguments in favour of the Konimeter were convincing.

In the endeavour which will be made to put a clear case before you, I have received much assistance from Mr. Paul Selby, Manager, Ferreira Deep, Limited, who has taken considerable trouble in order to procure the photomicrographs which illustrate this paper, and who has granted me every facility throughout; from the Miners' Phthisis Prevention Committee; from Mr. A. J. R. Atkin, who did a good deal of experimental work on the Konimeter on behalf of that Committee; and from many others who were interested in this question. I wish to acknowledge my thanks and obligation to all who have helped.

The study of miners' phthisis has led to the classification of dust in mine air into two types, known respectively as "injurious dust" and "non-injurious dust."

Reference to the report of the Miners' Phthisis Prevention Committee, 1916, will show that the majority of particles extracted from the lungs of miners who have succumbed to this disease, is less than 2 microns (1/12500 in.) in diameter. Thus the term "injurious dust" might correctly be confined to such particles. For practical reasons, and any error is on the safe side, the definition has been made to include all particles up to 5 microns in diameter, and it is in this sense that the expression is used in this paper.

This division of dust into two types seriously complicated the dust sampling problem. If we may judge from the many controversies and differences of opinion that exist, it would appear that the necessity for making such a distinction is not generally appreciated, but there is only one standpoint from which this problem should be viewed—that is the miners' phthisis standpoint. Then the one type of dust is of vital importance while the existence of the other is merely of academic interest. This point has been emphasized because it is essential to extend our knowledge of the occurrence and amount of this injurious dust in mine air, before reasonable steps can be taken to lessen or eliminate miners' phthisis.

The failure of the sugar-tube method at present officially in use on the Rand to show up satisfactorily the quantity of injurious dust, has always been recognised. The gravimetric expression of its results seems useless while it is impossible to eliminate all dust over 5 microns in diameter, and when the finest screen available allows particles up to 40 microns in diameter to be included in the weight. It would appear under these conditions that the weight of a sample is largely that of its coarse content, and an attempt will be made by means of photo-micrographs to prove this to be the case. Theoretically, it is of course obvious, since the weight of particles of a similar shape varies as the cube of the diameter, and a 40 micron particle would thus be equal in weight to 64,000 one-micron particles. It is doubtful whether the injurious dust in the worst samples obtained on the Ferreira Deep would weigh as much as 3 mgs. per cubic metre, and yet the number of particles is at least 1,000,000,000, and may easily be 8,000,000,000. Better results are obtainable if the sugar-tube sample is submitted to a grading analysis by which particles over 12 microns may be excluded, or the dust may be counted under the microscope. Both these processes are impracticable in dealing with a large number of samples owing to the time and labour involved.

The importance of arriving at a reliable method of estimating injurious dust will be recognised when it is remembered that legislation has already attempted the detailed treatment for the allaying and prevention of dust, while the past unsatisfactory method of diagnosis only indicated the advisability of rules for the general treatment.

We are indebted to the perseverance and ingenuity of Mr. R. N. Kotzé, the Union Government Mining Engineer, for a simple solution by means of an instrument he has devised and called a Konimeter.

It is the main purpose of this paper to point out the value of this invention, and to provide an easily accessible account of the method of using it, which should be of use not only to dust samplers on the Reef, but through the wide circulation of the *Journal* of this Society, to all those interested in this problem in other parts of the world. In addition, it is hoped that its claims to supersede the sugar-tube method will be established.

Description of the Konimeter.—The Konimeter is a simple mechanical arrangement for causing a known quantity of air to impinge at a high velocity through a fine nozzle on to the surface of a glass slide which is thinly coated with vaseline.

The method of accomplishing this can be readily followed from the working drawings (Fig. I.).* A piston, actuated by a spiral spring, is contained in a cylinder of such a size that on release of the spring which is held compressed by a trigger-catch, it moves through a space equivalent to 5 ccs. This small intake pump is mounted in a handpiece in such a way that it can draw air from a cell which is formed by an annular rubber ring attached to the frame, and a vaselined glass slide which is pressed against the ring by a flat spring, thus making an air-tight joint. This cell communicates with the outside air through a conical nozzle which tapers in diameter from 1·5 mm. to 0·6 mm. The small end of the nozzle is adjusted close to the glass slide. On each intake stroke of the piston air rushes up this nozzle and deposits its dust content in a circular spot. The size of this spot depends upon the amount of dust in the air, and is usually 0·6 mm. to 1·0 mm. in diameter. Two or more puffs may be used to form a single spot if it is thought that the dust content of the air is low.

The size of the nozzle, and the speed at which the piston moves, show considerable variations in different models of the konimeter. Nozzles are in use from 0·6 mm. to 1·0 mm. in diameter at the small end. For the purpose of determining the piston speed Mr. Kotzé has designed a simple apparatus consisting of a calibrated timing rod to which a bristle, or a piece of fine wire, is attached, and a simple catch, which operates the trigger of the Konimeter and vibrates the timing rod simultaneously. The vibrations of the rod are recorded on a blackened sheet of paper or mica which is fastened to the Konimeter by a metal clip—this clip fitting in between the guide and the spring. The arrangement gives an accurate measure of the time taken for the piston to complete its stroke, and from this the velocity of the air through the nozzle may be easily calculated.

Tests made with a large number of Konimeters show variations in air velocity between 20 and 175 metres per second, and Mr. Atkin finds that a velocity of less than about 30 metres per second will not produce the adherence of all the fine dust, while a velocity of 175 metres per second causes the vaseline to spread unless the coating is very thin and even. Velocities between 30 and 120 metres per second give satisfactory results.

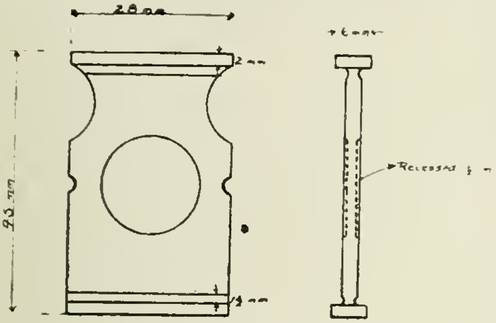
As many as nine spots may be made on the slide by slightly moving the glass slip after making each spot. It is usual to arrange these spots in parallel rows. On the Ferreira Deep we take from four to six spots on each slide, and reserve one slide for each place. For example in a drive 6 spots might be taken at equal distances from the entrance to the face. These then form a guide not only to the condition at the face, but also to conditions which previously existed. In a stope one spot would be taken of the air entering the stope, another of the air leaving the stope, while the remaining four would be taken at different places in the stope.

The slides used are 1½ in. by 1 in. glass slips with ground edges. These are cleaned after use and should be polished with a soft cloth before the application of the vaseline. The vaseline may be applied with the finger or by the flat piece of rubber, but the best result is obtained by spreading it with a glass rod. The coating should be as thin and smooth as possible. Before use the slides are examined under the microscope to see if the vaseline is free from dust, and if so, they are then placed, vaseline downwards, in a metal container which holds two slides.

---

* See supplement to this *Journal*.

The metal containers are shaped thus:—



The recess prevents contamination of the vaseline, and preserves the spots. The slides are attached to these containers by rubber rings. In removing slides the rubber ring should be rolled down to near the end of the frame, when one slide can be readily taken out without danger of moving the other. A box to contain six metal holders and the Konimeter will be found convenient for taking underground.

The Konimeter is provided with a spare glass slide, which is coated with vaseline and placed in position. Before taking a sample several puffs are made on to this slide to remove all trace of the last sample which might remain in the nozzle. On cold days moisture in the nozzle must be removed before taking samples, unless the Konimeter has been warmed before taking it underground, when moisture will not form.

Since the introduction of the Kotzé Konimeter another type has been made which utilises the same principle. Instead of taking the spots on microscope slides, the spots are formed near the periphery of a circular disc of glass. As many as 30 spots may be taken on each disc. These discs are not so easily handled under the microscope, and actually thirty samples could not be taken, as it is necessary to remove the traces of the previous sample from the nozzle after each set of spots, by making several puffs. It may be urged that there is less danger from contamination, but this may be neglected because contamination seldom occurs with the Kotzé Konimeter. The spots taken on the microscope slides used with the Kotzé Konimeter can be preserved by cover glasses, and may be photographed later should it be desired.

The Microscope and the Method of Counting.—The stage of the microscope should be marked off so that spots may be readily found.

Some difficulty may be experienced in obtaining the correct combination of objective and eyepiece. The size of the field depends on the objective and on the tube length, and it should be at least 1 mm. in diameter and not greater than 1·5 mm. The ruled glass supplied by a local firm is divided by lines 0·5 mm. apart so that if this is examined under the microscope two to three divisions should be visible. A ½ in. objective gives a field of suitable size, any necessary adjustment being made by altering the length of the microscope tube. It is advisable to use a high-power eye-piece. The method of counting the number of particles in a spot is important, and here a method is proposed which is theoretically perfect and very simple. It was adopted on the Ferreira Deep at the suggestion of Mr. Selby. A circular cover glass, which is placed on the diaphragm of the eye-piece, is ruled as shown on Plate A, No. 1.

The lines make an angle of 18° with each other so that a count of the total dust in both sectors is one-tenth of the total count of the spot, *i.e.*, $\frac{18^\circ \times 2}{360^\circ}$. Two lines are ruled outside the sectors at such a distance that they appear to be 5 microns apart, as a guide to the eye to enable the size of the particles to be estimated. If a spot is produced by a 5 cc. puff the dust in both sectors will equal the dust in 5/10 cc. = 0·5 cc., so that twice the count gives the dust per cc. If a 10 cc. spot has been taken the count gives the number per cc. direct. The sectors are divided by lines 50 microns apart to facilitate the counting of large numbers of particles. The ruling of the lines so that they will be 5 microns apart presents no difficulty. Assume that the field is 1 mm. in diameter and that 20 divisions ruled 0·5 mm. apart are visible when the ruled glass is placed on the diaphragm of the eyepiece. We then have on looking through the microscope:

20 divisions = 1 mm. field = 1000 microns.

1 division = 1/20 mm. field = 50 microns.

1/10 division = 1/200 mm field = 5 microns.

and as each division is ½ mm. wide, it will be necessary to have the lines ruled 1/20 mm. apart to obtain the 5 micron lines.

The eyepiece may be turned round and additional sectors counted, if desired. If the amount of dust is small the whole spot can be counted. The result is usually expressed as the number of injurious particles (under 5 microns) per cc., and the percentage which this number bears to the total count is also given.

The following objections have been raised against the Konimeter.—

1. The small quantity of air used to form the sample.
2. The danger of contamination in changing the slides.
3. The difficulty of counting, especially when oil and soot are present in the air.
4. The failure of the Konimeter to make a dust spot on all occasions.
5. The difficulty of making standard instruments.
6. The labour involved in counting the dust particles.
7. The personal factor introduced in counting.

These objections will be dealt with in turn.

1. The quantity of air used to form a sample is immaterial, provided that the amount used is representative of the air in the immediate neighbourhood. The nature of the air itself, its continual movement, etc., allows for the fairly equal distribution of the injurious dust in a short time, even assuming that this dust is incapable of producing an equal distribution on its own account. Samples taken, at intervals, in air with a more or less constant dust content, such as upcast air in a shaft, give spots with practically the same count, proving that a 5 cc. sample is quite sufficient. In places where a variable amount of dust is being produced, a variable count is obtained in different spots as would be expected. An unreliable result would be obtained if only one spot were taken under these circumstances, but if a number of spots be taken spread over an interval of, say, five minutes, any error would depend not so much upon the amount of air which formed the samples, but upon how far the dust sampled during this time was representative of the dust produced during the shift.

2. Contamination in changing the slides is rare. If it is known to have occurred underground, a fresh set of spots may be taken. Contamination is more likely to take place in coating the slides with vaseline, but it can then be detected before the slides are used. Even if it does occur, the effect may be eliminated in most cases by determining the average amount near the spots, and by making the necessary subtraction from the count.

3. Oil has never been noticed even when artificial means were adopted to produce it. Carbon sometimes occurs in samples from badly ventilated places, and is shown as large grey granular masses when dark ground illumination is used, and is easily recognised. (See Plate A., Nos. 6 and 7.)

4. Failure to make a dust spot. The best answer to this objection is to analyse the results obtained at the Ferreira Deep, Limited. Since the middle of September a record has been kept of all the samples, even if no spots have been counted on a slide. In the majority of cases the spots have been spoilt in handling the slides, and in others the spots which have been found gave so small a count that the dust in the air may have been insufficient to produce a spot which could be recognised as such. In all these cases the fault is not with the Konimeter. The failures may be recorded thus:—

On 3 slides — 0 spots were counted
,, 2 ,, 1 ,, ,,
,, 1 ,, 2 ,, ,,
,, 3 ,, 3 ,, ,,
,, 2 ,, 1 ,, ,,
,, 8 ,, 5 ,, ,,

On these slides there should have been a total of 112 spots, and only 61 were found. On 5 of the slides the average count was 16 particles per cc., so that it is possible that some of the spots escaped detection owing to their small dust content. In the three cases where no spots were found the vaseline was smudged by handling the slide on the surface. Other spots were spoilt by placing cover glasses on the slides before counting. These figures give a rough idea of the loss to be expected from all sources. In all 1,990 puffs gave 1,939 spots, a loss of 2·6 %.

One case is reported where the loss was over 70 %. There is a serious source of error which may account for this extraordinary result. If the flat spring does not cause the glass slide to press evenly all round the rubber ring, a gap is liable to be formed on one side, and air then rushes through this opening instead of up the nozzle. If a very small gap is formed air might also come up the nozzle and form a spot, while the air which passes between the ring and the slide would deposit some of its dust content on the vaseline. Under these conditions it is possible to have spots which are unreliable, as the quantity of air used is unknown, and contamination which cannot be accounted for, unless this source of error is detected. It is, therefore, always necessary to test the action of this spring by closing the nozzle and releasing the piston. If there is no leakage the piston will not move, or will do so very slowly.

5. All that is necessary in order to make standard models of the Konimeter is to arrange that the volume of air drawn in on each stroke of the piston should be the same and of a known amount, and that the velocity of the air through the nozzle should be within certain wide limits, as mentioned before. The first does not seem difficult to accomplish, while the second can be adjusted at any time, by altering the shape of the spring which actuates the piston. The nozzle may vary from 0·5 to 1·0 mm. in diameter at the small end without producing discordant results, but a diameter of 0·6 mm. is preferable.

6. If six spots have been taken on a slide these can be found and counted in about ten minutes. If during a morning underground the dust sampler takes eight slides of six spots each, or twelve slides of four spots each, he can have all the results worked out on the same day, and all the slides cleaned and coated with vaseline ready for the next day without working overtime.

If there have been any breaches of the dust regulations which require that a charge should be laid against any person or persons, his report to the manager can contain the results of the dust sampling, and it can be sent in on the same day that the regulations were broken.

7. With but little experience it is found that the counts of the same spots made by two samplers agree within 10 %.

Mr. Selby, Manager, Ferreira Deep, Limited, has kindly given me permission to make full use of the results obtained on that mine with the Konimeter. These date back to the middle of August, 1917, and although fairly definite conclusions will be drawn from them, it should be understood that these are only based on the experience of a few months. It is hoped that in discussion further results will be forthcoming from other mines on which the Konimeter has been in use.

The sampling has been done in most cases by the dust sampler of the mine. This position has been held by two different men at various times since August last. Neither had any previous experience of the Konimeter, nor of the use of a microscope.

A number of samples have been taken at the same time as the sugar-tube sample—not for the purpose of establishing a relationship between the two methods—but to show that the gravimetric results depend on the character of the dust and not on the number of injurious particles present. On an average six spots form one sample.

Table "A" shows these comparisons, while Table "B" shows the average of the total number of Konimeter samples for different classes of work.

The photo-micrographs with which this paper is illustrated have been made by Mr. Selby and myself, with an apparatus kindly lent by Mr. Sallo Epstein of Commissioner Street. The magnification in all cases is 40 diameters. Some of the pictures show the sectors as used for counting. A few

TABLE "A."

DESCRIPTION.	Number of Samples.	Number of Particles under 5 microns per cc.	of under 5 microns to total dust.	Gravimetric Result mgs. per cu. metre.	Particles in millions per mg.
Upcast Air	9	49	96	1·5	33
Downcast Air	11	26	94	3·2	8
Drives (Axial Water Feed Machines)	7	328	99	4·9	67
Drives (Reciprocating Machines) ...	3	230	98	1·0	58
Raises (Axial Water Feed Machines)	11	313	99	3·5	89
Winzes (Reciprocating Machines) ...	5	484	96	15·0	32
Ore Bins	27	70	93	1·2	17
Stopes (Axial Water Feed Machines)	7	129	97	3·6	36
Stopes (Reciprocating Machines) ...	78	102	96	1·1	25
Stopes (Hammers and Reclamations)	32	49	93	3·0	16

TABLE "B."

DESCRIPTION.	Number of Samples.	Number of Particles under 5 microns per cc.	% of under 5 microns to total dust.
Upcast Air	31	61	96
Downcast Air...	23	39	91
Drives (Axial Water Feed Machines)	13	353	98
Drives (Reciprocating Machines)	5	307	98
Raises (Axial Water Feed Machines)	32	315	98
Winzes (Reciprocating Machines) ..	8	181	97
Ore Bins	48	86	95
Stopes (Axial Water Feed Machines)	11	178	98
Stopes (Reciprocating Machines) ...	118	127	97
Stopes (Hammers and Reclamations)	35	16	93
Blowing out Holes	5	170	95
Blasting Dust... ...	5	320	88

photographs show the method of dark ground illumination, but this is unsatisfactory from the photographic point of view, although it makes counting easier. Ordinarily direct illumination gives better results, but in order to obtain the necessary contrast, sharpness of focus has been sacrificed to a small extent. In any case this magnification is insufficient to show the outlines of the dust particles properly.

With most of the photographs the corresponding weight by the sugar-tube method is given, and these comparisons form an optical demonstration to prove that the weight depends on the character of dust and not on the amount of injurious dust present. The comparisons must be made with the average of the total number of spots obtained, and not with the particular spot which has been photographed, as this only shows the type of dust produced, and may not be an average spot so far as the count is concerned.

My closing remarks will fulfill a duty which we all feel is owing to Mr. R. N. Kotzé, on account of the work he has done in this subject. For some years past he has spent much of his spare time in the attempt to discover a better method of dust sampling. This paper achieves one of its objects, if it adds to the number of those who wish to congratulate Mr. Kotzé on the success which has at last crowned his efforts. We appreciate the spirit which prompted him to place his invention at the disposal of us all without any restrictions, so that there should be nothing to impede its immediate application to the study of a disease which has had such disastrous effects on the miners of the Rand.

DESCRIPTION OF THE PLATES.

PLATE A

No. 1.—This shows the sectors as used for counting. The ruling was designed for a different objective from that used in photographing.

No. 2.—This is an example of dark ground illumination as used for counting. It represents dust from air in a skip in which men were being hoisted, and illustrates the facility of sampling. The average count of 6 spots per cc. = 37 = 90% of the total count.

No. 3. *Dust from a Change House.* Particles under 5 microns per cc. = 26 = 87% of the total count. Average count of 6 spots per cc. = 76 = 71% of the total count.

The percentage of non-injurious dust is high. The largest particle is 40 microns in diameter.

No. 4.—*Dust from a Drive with Axial Water Feed Machines.*—Particles under 5 microns per cc. = 264 = 97% of the total count. Average count of 6 spots per cc. = 147 = 96% of the total count.

Note the fine character of the dust. The largest particle is 7 microns in diameter. The weight returned by the sugar-tube method for this type of dust is usually low.

No. 5.—*Dust from a Hammer Stope.* Particles under 5 microns per cc. = 16 = 73% of the total count. Average count of 6 spots per cc. = 11 = 82% of the total count.

This is typical of hammer stope dust. The dust is coarse, and usually gives comparatively high weights by the sugar-tube method. The largest particle is 25 microns in diameter.

Nos. 6 and 7.—*Carbon Contamination.*—Average count of 4 spots per cc. = 12 = 84% of the total count. Carbon in the form of soot seldom occurs in spots taken under normal conditions. It was produced artificially in a dead end for the purpose of these illustrations. It is usually present in large granular masses, which have a grey appearance with dark ground illumination. The greater contrast of the quartz particles is apparent.

No. 8. *Dust produced by Blowing-out Machine Holes with Water.* Particles under 5 microns per cc. = 378 = 98% of the total count. Average count of 6 spots per cc. = 302 = 96% of the total count. The largest particle is 20 microns in diameter.

No. 9.—*Dust produced by Blowing-out Machine Holes with Air.*—Particles under 5 microns per cc. = 202 = 93% of the total count. Average count of 6 spots per cc. = 238 = 95% of the total count. The largest particle is 50 microns in diameter.

These two illustrations show the coarse character of the dust produced by this process. It always give large weights by the sugar-tube method, evidently due to the large particles which are forced into suspension in the air. Before the introduction of the Konimeter. experiments were made on the Ferreira Deep by washing out the holes with clean water before blowing out with air. but the gravimetric results showed no appreciable diminution. The experiments will now be repeated to see if the amount of injurious dust is lessened

No. 10.—*Dust produced by Blasting in Stopes.* Particles under 5 microns per cc. = 1,000 = 89% of the total count. Average count of 6 shots per cc. = 525 = 88% of the total count. The largest particle is 15 microns in diameter. The percentage of coarse dust is high.

No. 11. *Dust in a Winze with Reciprocating Machines.*—Particles under 5 microns per cc. = 652 = 98% of the total count. Average count of 6 spots per cc. = 700 = 99% of the total count. The largest particle is 10 microns in diameter. Our experience on the Ferreira Deep has shown that high counts are common in winzes. This might be due to the small quantity of water used. but insufficient results have been obtained to prove that winzing is more dangerous than raising.

No. 12. *Dust from a Tailings Dump on a Windy Day.*—Particles under 5 microns per cc. = 168 = 74% of the total count. Average count of 6 spots per cc. = 80 = 79% of the total count. Weight by sugar-tube = 7·8 mgm. per cubic meter. There is a large proportion of coarse dust. The largest particle is 40 microns in diameter.

PLATE *B*.

No. 13.—*Dust from a Crusher House.*—Particles under 5 microns per cc. = 212 = 87%, of the total count. Average count of 6 spots per cc. = 111 = 70% of the total count. Weight by sugar-tube = 5·5 mgm. per cubic meter. The largest particle is 15 microns in diameter.

No. 14.—*Dust from a Change House.*—Particles under 5 microns per cc. = 26 = 65%, of the total count. Average count of 6 spots per cc. = 18 = 64% of the total count. Weight by sugar-tube = 3·6 mgm. per cubic meter. The largest particle is 25 microns in diameter. The proportion of coarse dust is very high.

No. 15.—*Dust from a Street on a Windy Day.*—Particles under 5 microns per cc. = 60 = 88%, of the total count. Average count of 6 spots per cc. = 35 = 97% of the total count. Weight by sugar-tube = 7·8 mgm. per cubic meter.

The proportion of coarse dust is much smaller than in the previous samples. but the size of individual particles is larger. The largest particle is 50 microns in diameter.

No. 16.—*Dust from a Stope with Reciprocating Machines.*—Particles under 5 microns per cc. = 102 = 98% of the total count. Average count of 6 spots per cc. = 86 = 97% of the total count. Weight by sugar-tube = 1·2 mgm. per cubic meter.

This sample is more dangerous than any of the preceding four, but the fine character of the dust accounts for the small weight. The largest particle is 10 microns in diameter.

No 17.—*Dust from a Stope with Reciprocating Machines.*—Particles under 5 microns per cc = 86 = 97% of the total count. Average count of 6 spots per cc. = 69 = 99% of the total count. Weight by sugar-tube = 2·4 mgm. per cubic meter. The largest particle is 7 microns in diameter. This dust is coarser than that in the preceding sample, and the weight is double, although the injurious dust is less.

No. 18.—*Dust from a Crusher House.*—Particles under 5 microns per cc = 152 = 93% of the total count. Average count of 6 spots per cc. = 43 = 95% of the total count. Weight by sugar-tube = 5·4 mgm. per cubic meter. The coarse type of dust accounts for the high weight. The large particle shown is not on the slide.

No. 19.—*Dust from a Drive with Axial Water Feed Machines.*—Particles under 5 microns per cc. = 622 = 99% of the total count. Average count of 12 spots per cc. = 411 = 99% of the total count. Weight by sugar-tube = 3·0 mgm. per cubic meter. Note the high percentage of injurious dust. The largest particle is 10 microns in diameter, and the fine character of the dust accounts for the low weight.

No. 20.—*Dust from a Winze. Machines had not started.*—Particles under 5 microns per cc. = 32 = 89% of the total count. Average count of 6 spots per cc. = 30 = 86%, of the total count. Weight of sugar-tube = 9·6 mgm. per cubic meter. The largest particle is 15 microns in diameter. The sample shows that the air is comparatively harmless, although it would be regarded as dangerous from the gravimetric result. Compare these results with those of No. 19.

No. 21.—*Dust from a Hammer Stope.*—Particles under 5 microns per cc. = 46 = 92% of the total count. Average count of 6 spots per cc. = 33 = 96% of the total count. Weight by sugar-tube = 5·1 mgm. per cubic meter. The largest particle is 20 microns in diameter. This is another example of the harmless character of dust from hammer stopes. The relative coarseness of the dust may account for the higher weights returned by the gravimetric method for this type of stoping than for machine stopes.

No. 22.—*Dust from a Stope with Reciprocating Machines.*—Particles under 5 microns per cc. = 582 = 99% of the total count. Average count of 12 spots per cc. = 633 = 99% of the total count. Weight by sugar-tube = 2·1 mgm. per cubic meter. The largest particle is 10 microns in diameter. The amount of injurious dust is about 20 times as great as that of the previous sample but the weight is less than half.

No. 23.—*Dust from a Stope with Reciprocating Machines.*—Particles under 5 microns per cc. = 794 = 95% of the total count. Average count of 12 spots per cc. = 216 = 96% of the total count. Weight by sugar-tube = 7·8 mgm. per cubic meter. The largest particle is 20 microns in diameter. The coarse dust will account for most of the weight.

No. 24.—*Dust from a Hammer Stope.*—Particles under 5 microns per cc. = 106 = 86% of the total count. Average count of 6 spots per cc. = 66 = 90% of the total count. Weight by sugar-tube = 6·6 mgm. per cubic meter. The largest particle is 25 microns in diameter. The high weight is again accounted for by the coarse character of the dust.

PLATE *C*.

No. 25.—*Dust from a Stope with Reciprocating Machines.*—Particles under 5 microns per cc. = 164 = 93% of the total count. Average count of 6 spots per cc. = 68 = 97% of the total count. Weight by sugar-tube = 12·6 mgm. per cubic meter. The largest particle is 20 microns in diameter.

No. 26.—*Dust from a Drive with Axial Water Feed Machines.*—Particles under 5 microns per cc. = 884 = 99% of the total count. Average count of 12 spots per cc. = 935 = 99% of the total count. Weight by sugar-tube = 3·6 mgm. per cubic meter. The diameter of the largest particle is 7 microns. This sample is one of the worst obtained. yet the weight is fairly satisfactory.

No. 27.—*Dust from an Ore Bin—Cars Tipping.*—Particles under 5 microns per cc. = 34 = 80% of the total count. Average count of 6 spots per cc. = 31 = 89% of the total count. Weight by sugar-tube = 10·5 mgm per cubic meter. The largest particle is 20 microns in diameter. According to the gravimetric result this would be considered a dangerous sample, and special efforts might be made to reduce the amount of dust. Compare this with No. 26.

No. 28.—*Dust from an Ore Bin—Cars Tipping.*—Particles under 5 microns per cc. = 443 = 91% of the total count. Average count of 12 spots per cc. = 297 = 87% of the total count. Weight by sugar-tube = 13·2 mgm. per cubic meter. The largest particle is 20 microns in diameter. The high percentage of coarse dust will account for the weight.

No. 29.—*Dust from a Raise with Axial Water Feed Machines.*—Particles under 5 microns per cc. = 602 = 98% of the total count. Average count of 6 spots per cc. = 176 = 96% of the total count. Weight by sugar-tube = 13·2 mgm. per cubic meter. The largest particle is 10 microns in diameter, but the dust is fairly coarse throughout.

No. 30.—*Dust from a Drive with Reciprocating Machines.*—Particles under 5 microns per cc. = 130 = 97% of the total count. Average count of 12 spots per cc. = 184 = 99% of the total count. Weight by the sugar tube = 5·1 mgm. per cubic meter. The largest particle is 30 microns in diameter.

No. 31.—*Dust from a Waiting Place in Upcast Air.*—Particles under 5 microns per cc. = 21 = 81% of the total count. Average count of 6 spots per cc. = 11 = 88% of the total count. Weight by sugar-tube = 3·6 mgm. per cubic meter. The largest particle is 15 microns in diameter. The weight is high for such a harmless sample.

No. 32.—*Dust from a Winze with Reciprocating Machines.*—Particles under 5 microns per cc. = 518 = 98% of the total count. Average count of 12 spots per cc. = 606 = 99% of the total count. Weight by sugar-tube = 8·1 mgm. per cubic meter. The largest particle is 20 microns in diameter.

No. 33.—*Dust from a Stope with Reciprocating Machines.*—Particles under 5 microns per cc. = 172 = 98% of the total count. Average count of 6 spots per cc. = 152 = 98% of the total count. Weight by sugar tube = 6·3 mgm. per cubic meter. The largest particle is 40 microns in diameter.

No. 34.—*Dust from a Stope with Reciprocating Machines.*—Particles under 5 microns per cc. = 56 = 97% of the total count. Average count of 6 spots per cc. = 31 = 95% of the total count. Weight by sugar tube = 3·0 mgm per cubic meter. The largest particle is 30 microns in diameter. The weight is high compared with the small amount of injurious dust.

No. 35.—*Dust from a Winze with Reciprocating Machines.*—Particles under 5 microns per cc. = 948 = 92% of the total count. Average count of 6 spots per cc. = 946 = 92% of the total count. Weight by sugar tube = 24·6 mgm. per cubic meter.

This is another example of bad conditions in a winze.

No. 36.—*Dust from a Street on a Windy Day.*—Particles under 5 microns per cc. = 61 = 87% of the total count. Average count of 6 spots per cc. = 31 = 86% of the total count. Weight by sugar-tube = 10·2 mgm per cubic meter. The largest particle is 30 microns in diameter. The weight is out of all proportion to the amount of injurious dust present.

The President: We have to congratulate Mr. Innes, Mr. Paul Selby, and other gentlemen on the Ferreira Deep for the excellent work they have done in connection with this question of dust sampling by the Konimeter. This Society is also to be congratulated on having had this most interesting and excellent paper read before it. The interest taken in this subject is very obvious, judging by the full house we have got here to-night. It is the best meeting that we have had for very many months, in fact some years.

There are one or two points which struck me with regard to this paper and, the first thing is, I do not know why I am here; I think I ought to be dead, and many of us who have seen these slides, heard this paper, and who have worked underground before there was any question of dust sampling at all, must marvel that we are still alive, and must thank Nature that it has fixed us up inside a jolly side better than we realise, in having kept the dust out to a certain extent. The science of dust sampling seems now to have reached such a point, judging by Mr. Innes' paper, that it is possible for us, when we have nothing better to do, to sit down and work out how many particles of dust we have in our chest, and to work back on the underground record; it might be an interesting thing to do!

What I want to know now is: What is the minimum amount of dust required under the counting system which would give us phthisis? That is one point. Another point is, that the gravimetric method of dust sampling would now appear to be antiquated, although it has done very excellent work. There is no doubt that the sampling of mine air by the sugar process has done an enormous amount to eliminate dust in the mines of the Rand. That was the first step: and now we appear to have something better.

When the sugar method of dust sampling first came into force, everyone was very keen—as they should be. Those of us, at any rate, who were responsible for the amount of dust produced underground, and, of course also, the officials of the Mines Department are very keen, had a great time chasing round to get down the dust contents in the mine. Mr. Kotzé, having invented the Konimeter, is going to give us another run for our money. We, who are responsible for the dust in the mines should not rush too much to begin with. We are all keen on eliminating dust entirely: but this counting method means that we shall have to consider the question again, and still go much more carefully into the methods of dust allaying underground. It would appear to me that, as the result of the work done on the Ferreira Deep, we are now, or should be, right hard on the track of eliminating phthisis on the mines, provided we make up our minds to do so; and I am sure all those who are in responsible positions with regard to the dust on the mines will, and can, now that they have this method, eventually eliminate miners' phthisis.

I would now ask Dr. Irvine, who knows something about the human dust sampler, the lungs, to propose a vote of thanks to Mr. Innes for his paper.

Dr. L. G. Irvine *(Member)*: I have much pleasure in proposing a vote of thanks to Mr. Innes for his most convincing paper, to which I have listened with very great pleasure. I have known about the Konimeter for some time, and the subject is therefore not entirely new to me.

I want, in the first place, to offer a few congratulations. First, I want to congratulate this Society. This is by no means the first, or even the fifth or sixth first-class paper that I have heard read before this Society on subjects connected with miners' phthisis, and I think this Society is to be heartily congratulated on having, all along, taken such a practical and important interest in this subject. The ttendance to-night demonstrates that interest, and reminds one of the great old days of this Society. I hope it will always flourish.

The second body of people whom I want to congratulate is the whole mining community in having as Government Mining Engineer a man of the capacity of Mr. Kotzé. Mr. Innes is following in Mr. Kotzé's footsteps. It was Mr. Kotzé who invented this instrument. He came to do that because, about the time when the report of the Miners' Phthisis Prevention Committee was published, although it was obvious that the Committee had done a great deal of first-class work and had been the means of bringing into operation many useful and practical measures directed against the production of dust in mine air, we just then, or rather Mr. Kotzé just then, was of the opinion that the gravimetric method of determining dust did not carry us far enough. It had done good work. It had shown clearly, for example, that blasting-dust, by the use of proper water appliances, could be reduced by 95%, and that was amply sufficient proof of the value of these appliances. But as Mr. Innes has shown us to-night, samples tested only by the gravimetric method would seem to show that street dust is very much more dangerous than that of most underground atmospheres. People really were beginning to believe something of the sort and were going about patting each other on the back and saying, "What more can you expect?" You can't expect us to make mine air any better than street air." Well, they were talking nonsense, as Mr. Innes has shown. Mr. Kotzé, therefore, has devised this new dust sampling instrument, which determines the number of particles and not weight, and which tends to overturn some of the old gravimetric results altogether. These results were not wrong, but they did not show us all that had to be shown. I think an immense amount of thanks is due from the mining community to Mr. Kotzé for having done that. We are now able to distinguish between the dangerous and the harmless samples much better. The Government Mines Department has been often criticised for lack of inspectors and lack of inspection, and all that sort of thing: well, this advance, at all events, has come directly from that Department.

The third set of people whom I want to congratulate are the people of the Ferreira Deep, on having such an energetic and keen surveyor as Mr. Innes, and I hope all the surveyors on all the other mines will take a lesson from what they have heard from him to-night. It seems to me that if all the mines were to take the same interest in their dust problems as the people of the Ferreira Deep do—I do not say they do not because I do not know—but I say if they did, it would show that the managements of the mines were really determined to abolish this dust evil as far as is practicable.

I think Mr. Innes' paper has been most convincing. It is a great thing to know, when it is proposed to desert one method in favour of another, that the second method is so much better, not only in accuracy, not only because it gives you the real determination of the *danger* of the dust and not merely its weight, since the danger of the dust is in proportion to number of fine particles which it contains—not only from that point of view, but because it is much more easily managed and involves much less labour. It does not take an intelligent man very long to master the application of this method: once he has mastered it, he will never go back to the sugar tubes again. The sugar tubes marked an important stage in dust determination, and a necessary one. But this takes us a stage further.

There are one or two points that come out rather curiously in this paper to-night. One that struck me was the amount of dust contained in places where axial water-fed drills are being used. When axial water-fed drills were first introduced they were thought to contain the solution of very much of the miners' phthisis problem; but it seems to appear from what we have seen on the screen to-night, that they do not. This question wants, however, a more complete investigation. I should like Mr. Innes to tell us what type of water-fed drills were being used in these determinations, because there are, as you all know, two classes of water-fed drills: those which deliver air and water at the bottom of the hole, and those which deliver only water, and it would have been very interesting if we had seen photographs showing whether there was any difference between these two types of drills. I do not think Mr. Innes gave us any samples on the screen showing the amount of dust in stopes after blasting; I imagine all he showed was in connection with working stopes. I think it would be an interesting addition to the series, because, as you know, blasting dust in stopes is one thing which cannot be allayed, so that what has to be done is to remove the men out of it, and it would be an interesting object lesson, at all events, if he had been able to show us one or two of these. I hope that the introduction of this method of dust counting will mark an enormous advance in the handling of the dust problem. When you know what dusts are dangerous, you know the particular mining operations to which your preventive measures should be specially directed. A great deal has been done already by the help of the older method. But there is plenty more to do. The phthisis problem is still a serious one. There is no doubt about that. I believe that men take a much longer time to contract miners' phthisis now than in the past; but to say they are no longer contracting it is, I think, a thing which cannot be truthfully said. It must be remembered also that at the back of the dust problem and the question of silicosis there is the other question of tuberculosis, and, before "phthisis," which is its ordinary name on the mines, is stamped out, that problem of the control of tuberculosis in itself must become a prime object of the movement to abolish chronic lung disease in miners. A good deal, of course, is being done in this direction already. It is part of the working of the Miners' Phthisis Act. But it is a part of the problem which must never be lost sight of.

This is not a paper that one can discuss straight away off-hand. I think, however, that the author has established all his points in favour of the Konimeter. Not all mines have been so quick to see its advantages as the people of the Ferreira Deep have shown themselves to be. There was a long discussion among old conservative folk who said: "Cannot you establish some relationship between the gravimetric method and this method?" But the thing is impossible, and there is no point in it. The mere weight of the dust sample means nothing in itself; the number of fine particles means everything. And that point, I think, Mr. Innes has clearly established.

I wish to congratulate him very much, and the Society, on producing a paper of such excellence.

Lieut.-Colonel D. Macaulay, S.A.M.C. (*Visitor*): It has been a very happy coincidence, while having a little breathing time from another sphere of influence, to tumble on a meeting of this importance to-night, because it makes me cast my mind back a few years, when the discussion of this subject was in its infancy. I think it was in the year 1905 that your then President asked me, for some obscure reason or another, to read a paper before the Society, and, not knowing anything about mining, less of metallurgy, and perhaps still less of chemistry, I had to cast about to find out what were the subjects that were really of importance to the mining world at the time. Together with my friend Dr. Irvine, I had been for a long time impressed with what we, in practice in those days, saw happening on the mines, that was, the appalling loss of life and incidental loss of efficiency which was being caused by our industrial disease on the Rand. Probably by happy inspiration, after consultation with Dr. Irvine, I consented to write something on what, for lack of a better term, we called "Safety Measures in Mining." That was really the beginning of the public discussion on this subject. I think it was in the year 1905; that is nearly 13 years ago. And what strikes me most to-night—there are several things which flash across one's mind after listening to a paper of the value of the one read by Mr. Innes to-night—what strikes me most is this. First of all, the crude methods that were employed at that time. We were really groping in the dark: we were pioneers; we were only cognisant of results on the mines and very little cognisant of the processes that were leading to that result. In an omniscient kind of fashion, Dr. Irvine and myself, I remember, laid down a formula, and were also wise enough to throw the onus of putting that formula into practice on other shoulders. We said the solution of the problem was quite simple; the solution being "ventilation for the gases and water for the dust," and we left it to the engineers to ventilate their mines and to supply water to allay the dust. We can see to-night how poor a formula that was. A lot has been done in these intervening years to allay the dust, with good results; but to say that we have got at the very root of miners' phthisis is probably not yet true.

Mr. Innes has given us a very excellent paper to-night; a most convincing paper, a paper I am very glad to have travelled all the way from Durban to listen to.

It is not sufficient to be able to prove that the dust exists in this appalling number of particles per c.m. That is not enough, although it is a step in the right direction; but it rests with Mr. Innes and others (and I hope they will not adopt the method Dr. Irvine and I adopted long ago, of laying the application of the method on others' shoulders), to find out what are going to be the practical methods of catching these fine particles of dust, which are apparently as elusive as the people we have been chasing for some time in German East.

The other things that struck me most in the discussion of this matter was that the dear old Chemical and Metallurgical Society is still taking the foremost lead, and I remember the time when there was a good deal of discussion in this Society as to the advisability of tacking on the word "Mining" to the title of the Society. I think what has happened since then has amply justified the action of the gentlemen who wanted to make this a Mining as well as a Chemical and Metallurgical Society; and I hope the Society will continue to take the same practical interest in this matter as they have done in the past, and with such success that they will eliminate this scourge from the Witwatersrand.

I congratulate Mr. Innes, in the first place, and, through him, Mr. Kotzé, for the admirable work they have done, work which is really of first-rate importance; and I congratulate the Society on the paper that has been read before it.

The President: Before the discussion is resumed on this paper, Major Pratt Johnson will reply to the discussion on his paper, which will throw a little more light on the manner in which rats contract silicosis underground.

SILICOSIS IN RATS IN A WITWATERSRAND MINE.

By J. Pratt Johnson, M.B., B.S. (Lond.), D.P.H. (Oxon.).

Printed in Journal, March, 1917.

REPLY TO DISCUSSION.

Major Pratt Johnson, S.A.M.C. (*Visitor*): Since I read my paper before this Society in regard to the occurrence of silicosis in rats which had been kept in the underground workings of one of the Witwatersrand mines, it has been discussed by several members at various meetings. Unfortunately, owing to my time being fully taken up with military duties in other parts of the Union, I have not been able to be present on these occasions. Mr. Rowland, however, has kindly kept me informed, and I have come here to-night to again bring the matter before you and to answer points which have been raised in discussion. As there are probably members here to-night who were not present on the occasion when I read this paper, I propose to briefly outline the nature and results of these experiments.

Early in 1914 Dr. Andrew Watt, of the Consolidated Goldfields, thought it would be a good thing to place a number of white rates in the underground workings of the mine to see if they contracted miners' phthisis. Arrangements were accordingly made with the manager of the Simmer Deep to place a number of white rats in places where they would be subjected to the worst conditions of the mine. These animals were kept underground continuously for varying periods up to four years, during which time—owing to the courtesy of the manager—they were carefully fed and looked after. Rats were removed, killed and examined at varying intervals from seven months upwards, and the results of these examinations formed the subject matter of this paper.

After preparing this paper, I found that your President, Mr. Hildick-Smith, in 1911 pointed out the advantages of investigating the question of silicosis in rats, and that such information would be of value in advancing our knowledge of miners' phthisis. More recently, Professor Beattie, on behalf of the "Royal Commission on Metalliferous Mines," carried out certain interesting experiments on guinea pigs. These animals were placed in a dusty atmosphere (artificially produced by means of a mechanical device in a closed box) for short periods of one or two hours a day, the periods of exposure totalling in one series of experiments 21 hours, and in another series 65 hours. These animals were subsequently killed and examined, and it was found that a differentiation could be made between different kinds of dust. Clay and cement were found not to be particularly injurious, whereas silicious dust always produced fibrotic changes in the lungs of the guinea pig. In a similar experiment carried out in a closed tent he endeavoured to imitate as far as possible, the dust conditions usually found in metalliferous mines. In this case, however, the guinea pigs did not show any definite changes in the lungs, but it appeared that if these experiments had been continued over a longer period, similar results would have followed.

The experiments, however, were carried out with rats which were actually placed in the underground workings of the mine, but it should be remembered that they were exposed to the dust and fumes continuously during the whole 24 hours.

It is necessary further to draw attention to the published results of an investigation in regard to some 30 or 40 brown rats which were recovered from the underground workings of one of the Witwatersrand mines. These animals were caught underground, killed and examined, and in no case, I believe, was evidence of silicosis found. It should be pointed out that these animals were trapped at the beginning of winter, and in view of our own researches in this field, these rats could only have been in the underground workings for a short time; in any case no evidence is available as to how long they had been there. It appears certain that they were surface rats which had been driven down the mine by the onset of the cold weather.

Since the publication of the statement that rats placed in these conditions do develop silicosis, no evidence has been brought forward in refutation. On the other hand, an examination which I have made of two further rats which had been exposed to mine air for a period of some twelve months showed marked silicosis of the lungs in each case.

I wish now to clearly represent as a fact that rats placed in a mine for a period of time varying with the nature of the conditions, develop a very definite pure silicosis, due to the inhalation of dust. The nature of the structural changes produced in the lungs of these animals can be readily diagnosed and differentiated from any other pathological condition. The analogy, moreover, between silicosis in rats and the fibrotic changes found in the lungs of gold miners, is both marked and striking. There is no reason why animal research in silicosis should be confined solely to rats. In view of the high resistance of rats to human tuberculosis, one is certain—apart from other reasons—that tuberculosis plays no part in producing the changes described above. The guinea pig, however, is easily infected with human tuberculosis. Consequently experimental study of the changes produced in the lungs of guinea pigs placed in the underground workings might prove of considerable value. There is no reason why any animal, including horses, mules, and birds, kept underground should not develop a condition of silicosis. Owing to the pressure of war work very little has been done during the past year on the experimental side, but I think that researches on these lines should be taken up by those who have opportunity and time.

I have listened with considerable interest to the paper read to-night setting forth the results of examinations of the dust found in mine air by means of the extremely ingenious apparatus known as the Kotzé Konimeter. Mr. Kotzé is to be heartily congratulated in providing a most useful method of investigating the dust content of mine air. It has always seemed to me that dust sampling, whether carried out by the gravimetric method or by the more recent method of direct observation, has been of the greatest use in demonstrating the constant presence of dust in mine air. An important point, however, to decide is what constitutes injurious dust, and, as Colonel

Macaulay so ably remarks, a still more important point is by what means can this injurious dust be eliminated from the mines. The Konimeter method of observing dust will provide records as to the presence or absence of injurious particles in each sample taken. When a sufficiently large number of records of these observations have been amassed, some information will be available as to the distribution of the dangerous areas and the comparative efficacy of the preventative measures at present advocated. While such information will be extremely valuable, yet on the other hand no experimental evidence is available as to what changes are produced in the tissues of the lungs when different dust contents are inhaled. This information, however, can be obtained by observing the changes produced in the lungs of rats exposed for varying periods from six months upwards to underground conditions, in respect of which numerous records of the dust content of the air breathed by the rats is made by the Konimeter method. All the available evidence goes to show that the re-action changes set in train by the inhalation of mine dust are essentially identical, whether the subject be man or a smaller animal. Under the circumstances, provided that the experimental animals are exposed to the mine air for the same period as the men, the condition of the lungs of these animals will indicate in some measure to what extent similar changes have taken place in the workmen. It is not necessary, however, for practical purposes to press the analogy too far. The information gained as the result of these experiments would show what dust contents are dangerous, and further information may be gained as to the relative value of different preventative measures and, moreover, in some way indicate the efficiency of the mine administration.

Comparisons have been made as to the relative value of animal experimentation and dust sampling. It is obvious from the foregoing remarks that dust sampling and animal experiments should go hand in hand, the one being complementary to the other. Animal research on miners' phthisis is undoubtedly a valuable asset, but I do not think it is likely to lead to any epoch-making discovery. What is required is careful investigation carried out on the above lines over a period of years.

It should be remembered that whereas the Konimeter method records the nature of the dust found at the particular time of the sampling, animal experiment reflects results of continuous inhalation of dust. The Konimeter method is an *intermittent* control, whereas animal experiment constitutes a *continuous* control.

The President: While we are all red hot on this subject, we will now make it open for discussion, and would like to hear anyone who has anything to say on this most important subject, so that we may be perhaps assisted in getting a little nearer to eliminating miners' phthisis. I think there are several here who are working underground most of their time—members of the Miners' Union and others, and if they have anything to say we should like to hear something from them from a practical standpoint.

Mr. A. McArthur Johnston (*Past-President*): I would like to associate myself with Dr. Irvine and Colonel Macaulay in congratulating Mr. Innes on the excellent paper he has placed before us this evening. We have listened with great interest to all he has said, and we appreciate the trouble he has gone to in preparing his slides. He has impressed us all with the value of the Konimeter as a means of registering fairly accurately the dangerous nature or otherwise, of the dust in mine air.

If I might at this time criticise his paper, I should like to say that he has been rather severe, especially whilst showing the slides, on the sugar method. I think that, as the introducer of this method on these mines now nearly six years ago, I may claim that it was a great advance on any method previously in use, and that had it not been for this method, the mines would not be to-day in the satisfactory conditions they are. It may have led us in the wrong direction in one or two cases, but I am not sure whether the Konimeter would have been much use to us seven years ago. We would very often have had great difficulty in counting the dust particles in these days, when the workers would come to the surface looking almost like millers. As Dr. Macaulay said, we must go by easy stages, and when another step has been made in the right direction, do not let us depreciate past methods.

I have been using the Konimeter on our mines since June last, and I was hoping that Mr. Innes would have helped us to-night in showing by his figures how mine air might be classed as good or bad. I was reading, not long ago, an account of dust estimation by Mr. E. Vernon Hill, of the Department of Public Health, Chicago. In this paper (see extract Metallurgical and Chemical Engineering, August 15, 1917) he quotes that by using an instrument—so far as I can judge somewhat similar to Mr. Kotze's—he found only one dust particle per 30 cc. of clean, outdoor air, and in a mechanically ventilated schoolroom, without air washers, one particle of dust per cc. of air. This seems very small indeed.

Some months ago we introduced the following rough method of determining the quality of mine air on the Consolidated Gold Fields mines:—

Under 50 particles of dust, per cc. of air —Very good

Between 50 and 100 particles of dust, per cc. of air.—Good

Between 100 and 200 particles of dust, per cc. of air.—Fair

Between 200 and 300 particles of dust, per cc. of air.—Poor

Over 300 particles of dust, per cc. of air —Bad

Now, looking at the figures quoted by Mr. Innes, and viewing the slides, one would be inclined to say that the conditions at the Ferreira Deep were not too good, if the above standard be any criterion. I noted, however, that his averages were nearly always well below the number shown on the slide, and I am therefore hopeful that his figures would roughly corroborate those quoted as possible standards under ordinary conditions. Included in this standardisation, there is, of course, the place of sampling. So far as we are concerned, the practice is to take a sample as near as possible to the head of the worker at the place being tested, but I should be pleased to hear Mr. Innes' method in this particular.

I would again thank the author for his interesting and instructive paper.

Mr. J. A. Woodburn (*Associate*): I think the paper to-night will form a classic in connection with the records of the Society. It is the result of a great deal of accurate experimental work, and as such, will be a very valuable record.

When Dr. Macaulay was speaking, he said that some twelve years ago he brought forward a formula, but he thought that had not had the desired result, and we still had to bring forward another formula. From a good deal of experience in mining I am inclined to think that his formula is still good.

It is something like the story I was reminded of when he was speaking, that of the Highlander who lived far away from civilisation. A visitor was there, and asked him how they got along when they were ill, they being so far away from any medical man. He said, they took whisky. "But, if you do not recover, what then?" "We take more whisky." Well, I think the formula of "Ventilation for the men, and clean water for the dust," still holds good, and if it has not brought the desired results so far, then we want more ventilation for the men and more clean water for the dust. It is from this point of view that I think it would have been interesting if the badly ventilated places had been compared with the better ventilated places, because I know it has been expressed that ventilation has a hurtful effect in stirring up the dangerous dust. I saw the report last year of the dust samplers, and was particularly struck with the fact that the dust in the air in the downcast shafts was as high as, and in some cases higher than, the dust in the upcast shafts. This, as explained to-night, may have been due to the dust in the downcast shafts having larger particles, which may not have been dangerous dust. That is the next step we want to take—to find out whether a well ventilated place has less hurtful dust than a badly-ventilated place.

From the number of slides Mr. Innes showed us, there were too many for me to follow very clearly and correlate on listening while he was speaking, but I certainly got the impression that the dust in rock-breaker houses, dust from dumps, and where trucks are being tipped at box-holes and ore-bins was not of the nature of dangerous dust, although, according to the gravimetric method it might appear to be fairly high. These were places all fairly well ventilated. Dust from winzes, raises and drives was rather bad, worse than in stopes with the same machines running.

It would be interesting and helpful if further experimental work were done with the object of showing whether a well-ventilated place was better from the point of view of dangerous dust. If double the quantity of air passed through a place naturally the percentage of dust will be halved, because the dust produced remains the same. When a place is well ventilated a great deal of very fine dust should be carried away whilst the men are out of the mine, but if not too well ventilated, except in the main roadways, dust is raised and settles again, and as time goes on there is an accumulation of fine dust, whereas if good ventilation is carried past the working places much of the fine dust would be carried out of the mine altogether.

Now that we have an instrument which shows what is the quantity of dangerous dust as distinct from total quantity of dust, it ought to be easy to make sufficient tests to prove whether a well-ventilated place is less dangerous than a badly-ventilated place.

Mr. Palmer Carter *(Member)*: I should like to pay a word of tribute to Mr. Innes for his most valuable and interesting paper. He has gone into the question of dust sampling with great thoroughness, and his tribute to Mr. R. N. Kotzé, for his most valuable invention is well deserved. Mr. McArthur Johnston has given us some most interesting remarks on the pioneer work connected with dust determination underground, when the gravimetric method was introduced for determining the amount of dust in the underground air samples. The gravimetric system gives no idea of the dust, whereas by the Konimeter method we are able to determine whether the dust is injurious or not.

Speaking as a mine manager, whose chief duty is to see that the numerous mining regulations are carried out, I should like to protest against having to carry out the two systems of dust determinations at present in vogue. The Government Mines Department are prepared to accept all underground dust determination by the Konimeter method, then why is it necessary to have to maintain both systems, as is, at present being done? I hope that we shall shortly be excused from continuing the gravimetric method.

The author's paper should raise considerable discussion, as it bears on one of the most important questions connected with our mines.

I should again like to congratulate him on giving us one of the most important mining papers that has been read for a long time.

Mr. F. C. W. Ingle *(Visitor)*: I think that, in the campaign against miners' phthisis, the paper we have heard to-night will really be epoch making, because it will now probably enable us to direct our attention more effectively to the weak points in our methods of fighting that awful disease. It looks very much as though, in the past, we have been running after white elephants in some respects. For instance, we have been led to believe that very bad conditions exist at ore bins and ore passes, due to the weight of dust contents in their neighbourhood, whereas, by Konimeter results, the number of dust particles present at these places, shows the atmosphere to be comparatively clean. Yet recent legislation has required that pronounced steps be taken and much attention paid to these points.

It has been a puzzle to many of us that so much attention has been directed to ore bins and tipping stations when the rock handled is always thoroughly wet. The sprays required by the regulations are heartily detested by natives working at these places, and it would seem, in the face of Mr. Innes' showings, that they are redundant.

I hope, in some directions where we are now handicapped by regulations requiring elaborate precautions, we may be freed from the inconvenience they occasion. On the other hand, I believe there are other places to which we are not now paying particular attention, yet, which are harmful to the men employed in their vicinity, and a source of contamination to the general mine atmosphere.

We had thought that, with the axial water-fed machines we had practically solved the dust problem as far as machine drilling is concerned. Now it would appear that, with the use of these machines, conditions may be much worse than with the old reciprocating type.

I think that Dr. Macaulay's point here is a very important one. We ought to know whether Mr. Innes' samples were taken when air was fed through with the water, or water only, and I think it will be found that, where the air and water are fed through together, the atmospheric conditions will be very much worse than otherwise, as you frequently get a certain amount of vapour coming from the hole, and it is to be expected that this vapour will carry quite a large quantity of extremely fine dust, accounting for the very serious results shown up by the Konimeter.

According to the latest regulations, in raising and back-stoping, no other type of machine than the axial water-fed is permitted. But it seems quite possible that this may prove another case where misleading data lead to mistaken measures.

I do not, however, think we are justified in condemning the axial water-fed machines on the evidence we have examined this evening, as Mr. Innes has obviously only shown us slides which illustrate most convincingly the defects of the gravimetric as compared with the Konimeter method of dust estimation, and seemingly the axial water-fed machines, by virtue of the extreme fineness of the dust they disseminate in the atmosphere, serve this purpose admirably. I do, however, think the results, so far obtained, show the immediate necessity for a thorough investigation concerning this type of machine with the more reliable apparatus now at our disposal.

As far as the accuracy of the Konimeter method is concerned, it seems to me an enormous advantage that, in the same time and with less labour, one may, with the Konimeter, take a number of samples, whereas, with the gravimetric method, one must, as a rule, be content with one at each point.

One sample, as we all know, is liable to contamination. With a number of samples, the average will be somewhere near the mark, and it must be remembered that this number is taken over a period which probably corresponds very nearly to the period occupied by the taking of one sample by the sugar tube method.

It seems hardly necessary to say anything more about the serious defects of the gravimetric method when the number of dust particles and not their weight, is what concerns us. But I hope, as a result of Mr Innes' paper, we will find that the Konimeter will take the place of the other method, and that we shall be enabled to fight our problems more effectively than in the past.

I also think the suggestion Major Pratt Johnson has made with regard to rats is a very useful one. We might use our rats as, what the miners term " sample takers." That is to say, on each mine there would be about a dozen rats labelled, respectively, " Winze rat," " Leyner Stope rat," " Holman Stope rat," " Ore Bin rat," and so on.

These rats, which might be housed in a wholesome place in the mine, could be taken daily, each by a miner representative of each class of work, to his working place at the beginning of the shift, where the rat would remain in the same conditions with the miner until the end of the shift, when it would be returned to the storing place. After a sufficient period the rats could be examined as to the condition of their lungs, and much valuable information as to the relative danger under all conditions of work on the mines would be secured.

It is reasonable to suppose that, what has taken place in the lung of the rat must also have occurred in that of the miner.

Mr. W. J. Carbis (*Visitor*): I would not like to see this meeting close without expressing my appreciation, on behalf of some of the miners who are here, and probably members of the Miners' Union, for the interesting paper we have listened to tonight. The average of us do not understand much about the French methods of measurements and weights; we do not follow your technical expressions too well, but one thing has convinced me, and probably those of us who are here to-night who are miners—and only common miners at that—that we shall have to take a keener interest in the recommendations which come from a Society such as this the members of which have evidently taken a keen interest in the underground conditions under which we have to live and work. The methods which there are for discovering the amount of injurious dust which we are breathing underground, have been an eyeopener for me; and, if most of our miners were to listen to papers of this description, it would probably influence them to take a keener interest in the carrying out of the recommendations of such Societies as this and of the Mines Department which interest themselves in these matters.

I do not know how our miners will take to the idea of sending down rats with us. As it is, we are sometimes called " Water Leyner Rats " now and, if rats are sent down with us, I do not know how they will take it.

I do not know much about this kind of business, but it reminds me of the time when I was a boy. Some of us then made an attempt to study physiology, and that kind of thing. At any rate, it recalls those days back to our minds when we did not worry ourselves very much as to whether experiments of this kind could be made to diagnose diseases of the human body. At any rate, we learnt, when we were young, that we were animals similar in structure to other animals.

With regard to the paper and the lantern slides—well, I happen to be running these axial drills myself. I have just given up the reciprocating drills for the axial fed drill, water Leyners, we call them, and I have now come to the conclusion that it is time I gave up all machines and supervised hammer boys. I do not know for my own part, that the author has proved conclusively that the axial water-fed drill is of more danger than the reciprocating drill, because, after all, one has to take into consideration the stopes where the samples are taken from; but, if that is proved, then thought in regard to the axial drill is going to be revolutionised. That is a certainty, and I think perhaps that it is time we chucked them all up. The slides which we have seen to-night are liable to frighten miners more than a bioscope picture! I am sure that the other members of our Association who are here to-night will be with me when I express their and my own appreciation of the papers which we have heard to-night, both from Mr. Innes and from Major Pratt Johnson. I also desire to express our appreciation to this Society for having invited us to this meeting to-night.

Mr. J. J. B. Pohl *(Visitor)*: On behalf of the Miners' Union also, of which I am Vice-President, I feel that it is my duty, first of all, on behalf of the Union, to voice my appreciation to Mr. Kotzé and to Mr. Innes for the vast strides they have made in detecting dangerous dust; but it has come like a death-knell to me, as a miner. I was always under the impression that, with the water Leyner machine the problem of phthisis was solved. Seeing the stringent measures that the Government and the Managements take with regard to water I thought if the mines could have been swamped with water there would be no dust, but my eyes have been opened somewhat rudely. I hope this Society, composed as it is of a lot of learned men and students, will be so successful in their research work that when next they invite us to a meeting of this kind we shall have an opportunity of thanking them and showing our appreciation on a successful solution of the dust problem, and not only of detecting it. We all know and we all realise that the dust is there. Although we all thought that miners' phthisis was losing its power over the workmen underground through the use of water, we find to-night that it is not so. I would like, and it would be a great boon to the miners of the Rand, if this Society could arrange for Mr. Innes to come out to the different towns along the Reef and give the same paper to us, say, for instance, in Benoni, Germiston, and so forth, and I can assure him that the Miners' Union will do its best to get the halls crowded with miners. I am rather disappointed there are only a few miners here to-night; but it is because they do not realise the real danger, and are all under the impression that it is water, water, and again water, that is dispelling miners' phthisis. In conclusion, I hope my suggestion will be acceded to and that Mr. Innes will be able to come along the Reef, so that we may all realise the real danger that we are running.

The President: There are one or two points I would just like to mention before we declare the meeting closed.

We have had a very interesting discussion on this important paper, and I am pleased that Messrs. Carbis and Pohl were here to-night to tell us what they think from their point of view. We, as a Society, are very pleased to see them here, and we only hope that they will come oftener.

There is one point that I think perhaps they should understand a little more clearly, and that is, the work that has been done in preparing and getting ready this paper which you have heard to-night is nothing like the final word with regard to dust sampling. This kind of work, as you may or may not know, takes a very long time, and, unfortunately, those of us who would be keen on research work have not enough time to give to this class of work. In this case the work has been done by Messrs. Innes, Selby and others, in the little time that they can spare; and after all, the results of their work, must not be taken as conclusive. There is much more work to be done yet before definite and final conclusions can be drawn. I think we must not condemn axial water-fed machines before we have complete data to go on.

I am glad the representatives of the miners do appreciate this work that has been done. This Society has been helping indirectly in improving life underground from the health point of view for very many years, and it has taken a good many years, as Col. Macaulay has said, to get to this stage, and it may take another eleven before we come to the conclusive stage. I do hope that the representatives of the miners will come again. We should like them all as Associates.

With regard to the suggestion of Mr. Pohl, that this paper should be given again at different centres along the Reef, that is a point which will have to be brought up before the Council, and also discussed with the writer of the paper. It cannot be decided now, but this Society's *Journal* has a wide circulation, and the remarks which have been made to-night may possibly be seen in the daily papers some time next week.

DEPARTURE OF THE PRESIDENT.

The President: There is one other point that I want to mention and that is, that this is my last meeting for some time. I consider it my duty to leave this country to go to England, and to take up some direct work with regard to the war, and, as I shall be leaving shortly, I take this opportunity of thanking you—the Council and the members of this Society—for the support you have given me while I have been President of the Society.

I may say that, unfortunately for the Society, other men more fitted for this work than I am, refused to stand at the beginning of this year for the election. I have tried to do my best, and I only hope and I am sure that the future Council and members will give my successors the same support that you have given me. I thank you.

Mr. H. A. White (*Vice-President*): Gentlemen, on your behalf I wish to convey to the President our very best wishes for his success in the new career he is going to adopt. He has made a great reputation in this country and in this Society. He is now seeking glory in other fields, he is seeking the bubble reputation even at the cannon's mouth. But we hope he will come back safely, and would like to assure him that we shall carry on the work that he has initiated as well as we possibly can.

Owing to the lateness of the hour the following were taken as read:—

SOME NOTES ON EXPLOSIONS OF FIRE DAMP, AND OCCURRENCES OF GOB FIRES IN NATAL

By Messrs. J. E. Vaughan (Member) and F. A. Stuart (Associate).

(Printed in Journal, June, 1917.)

REPLY TO DISCUSSION.

Our paper has not been discussed to any great extent, which we regret, as many members must have had experience of underground fires due to spontaneous combustion, and could no doubt have given valuable information regarding experiences with such occurrences.

Mr. C. J. Gray is quite correct in his remarks; the mining regulations in Natal were made more stringent in May, 1910, just prior to Union, and the explosion quoted as occurring at the Elandslaagte Colliery really occurred at the Campbell Colliery. We apologise to members for these errors, and regret that we inadvertently libelled the Elandslaagte Colliery.

Mr. W. T. Heslop discusses our paper at some length, and remarks that the reduction of accidents and explosions is not due to the new mining regulations.

We stated that previous explosions in Natal would have been prevented had the existing mining regulations been in force, *and rigidly adhered to by all concerned*, and we adhere to the statement.

Mr. Heslop says that other factors come in and cause explosions, such as a mine manager taking undue chances, or the men on some mine being "wasters," this appears to us to support our view that where the mining regulations are broken accidents will occur. We would remark that mining regulations are drawn up as the result of experience in this and other countries, and after conferences with owners, managers and men, and are really the opinions of many mining people put in the form of regulations.

We had not the slightest intention of belittling the efforts of mine managers, mine officials and miners to avert explosions, and we realise that the most careful and strict manager may have an explosion in his pit, but many cases are known, not only in Natal but in other countries, where an explosion has been caused through a deliberate act of carelessness which was a breach of Mining Regulations.

We admit that Mr. Heslop was the originator of the theory that the Natal coals, which are semi-anthracitic, are more liable to spontaneous combustion than the bituminous coals, but Mr. Heslop admits his inability to give scientific reasons for this theory. In support of his contention that only those coals in Natal which have been subjected to igneous action are liable to spontaneous combustion, Mr. Heslop quotes from the *Transactions* of the Institute of Mining Engineers, Vol. LIII., Part 4, a letter from Mr. J. Forgie describing how in a certain case in the coking coals of Kilsyth, a road when being driven through a dike, encountered coal very liable to spontaneous combustion on one side; from this Mr. Heslop deduces that coal from which a portion of the volatile matter has been driven off is more liable to spontaneous combustion than coal which has not been so affected. It is only fair, however, to quote Mr. Forgie more fully on this subject. He says: "Many roads have been driven through these whin dikes, but only in *one* case was heating experienced." He also further states: "This incident was, of course, special and local, and not common to the seam generally." Mr. Heslop's deduction from Mr. Forgie's experience would therefore hardly appear to be justified.

As far as our knowledge goes, we believe the coals which are notorious for spontaneous combustion are those of the bituminous and coking varieties. There are, no doubt, instances of coals of the semi-bituminous and even of the anthracitic varieties being liable to spontaneous combustion, but such instances are the exception rather than the rule, and before arriving at definite conclusions on the subject as far as Natal is concerned, it is desirable that evidence from many collieries should be considered rather than that deductions should be drawn from one colliery only.

In regard to Mr. Heslop's remark that he has "yet to learn of a fire in Natal that could not be traced back either to coal which has been subject to igneous action in greater or less degree, or else has occurred in a seam which contained a band of very inferior coal," we would say as far as the first part of his contention is concerned, in Natal coals are being mined containing as high as 30% of volatile matter, and spontaneous heating has occurred in such mines. It is of course easy to say that even such coals have lost a proportion of volatile matter through igneous action, and it would of course be impossible to state that such has not been the case, but to argue that because spontaneous heating has occurred in certain coals such coals must therefore have been subject to igneous action, is hardly sound reasoning. The facts are that not only are certain anthracitic and semi-bituminous coals in Natal subject to spontaneous combustion, but *also* coals highly bituminous in character. It is therefore equally essential to guard against gob fires in the bituminous as in other areas where conditions favourable to spontaneous combustion exist, such as where the two coal seams are close together.

In regard to spontaneous combustion being set up by a band of inferior coal in the seam, we know of no case in Natal where a gob-fire could be definitely attributed to this cause. It does not necessarily follow that an inferior band of coal is more liable to heating than the other portion of the seam. An inferior band of coal *may* be more liable, on the other hand it may be less so, there is no evidence. If inferior coals are more liable to spontaneous combustion than seams of better quality, we would point out that almost all the fires which have so far occurred in Natal have taken place in the Hatting Spruit and Dannhauser areas, and we think Mr. Heslop will agree that the coal in these areas is as good, if not better, than that in other parts of Natal. It might be argued that the reason for fires occurring in these areas is the leaving in of the top seam in the goaf, and this is no doubt the main reason, but fires have also occurred where the top seam only has been worked, or where a heap of coal has accumulated in an old road.

We may add that although pyrite does not play such an important part in causing spontaneous combustion as was once supposed, it is, however, by no means an unimportant factor. Casual examination of the coal in the neighbourhood of gob fires in Natal reveals, as a rule, little conspicuous pyrite, but a close examination almost invariably discloses this mineral, in the form of Marcasite (which is notoriously unstable), scattered throughout the coal in exceedingly fine particles. Whether igneous action has had anything to do with the production of this form of pyrite we do not know, but it seems not improbable that the abundance of this mineral disseminated throughout the coal in certain areas greatly facilitates oxidation.

In regard to Mr. Heslop's remarks re building off gob-fires, we merely give our own experience as to the best method to adopt, and especially emphasised that "no two fires are alike, therefore no hard and fast rule can be laid down, and each case must be considered on its merits." To give details in regard to the recovery of the Natal Navigation Colliery after the explosion produced by the gob-fire there would have unduly lengthened the paper.

THE CONSTRUCTION AND MAINTENANCE OF SLIME DAMS.

Jas. E. Thomas (Past-President) and
E. A. Osterloh (Member).

(Printed in Journal, June, 1917.)

REPLY TO DISCUSSION.

Mr. J. E. Thomas *(Past-President)*: The authors desire to tender their thanks to those who took part in the discussion on this paper, but are at the same time disappointed that the subject has not been more thoroughly thrashed out and experience gained during this exceptionally wet season placed on record.

Mr. H. A. White's suggestions relative to the importance of selecting sites for dumps, slime dams, etc., in consultation with a metallurgist, when laying out the general plan of a mine at the start, are very much to the point, and the authors trust that the suggestions will not have been made in vain.

It might not, however, be advisable to arrange that one sand dump only should be laid out so that it and it's centre will deal with all residues for the life of the mine, as that would mean an expenditure of power in hauling trucks and sand residue an unnecessary distance, and would be analogous to installing the slime residue discharge pipe at the ultimate height to which it is intended to build the slime dam. It might be possible to arrange matters so that the average length of hauling, over the life of the mine, would not be excessive, by allowing for two or perhaps more dumps on the same principle.

The authors are indebted to Mr. Newton for pointing out an unfortunate error in the paper, which states "Two dams with a total circumference of 6,000 to 7,000 yards . . . will be found sufficient to receive residue from a plant capable of treating up to 50,000 tons per month." It is, of course, obvious that 6,000 to 7,000 ft. is meant. The actual circumference of the dams referred to in the paper is approximately 2,250 yards.

Mr. Newton's statement that it is not necessary that the construction of slime dam walls should be of the same strength and nature as those constructed to hold water is in agreement with the views held by the authors, though local conditions might sometimes make it advisable to more or less imitate the construction used for the walls of water reservoirs, and prove cheaper in the long run.

Mr. Newton is somewhat wide of the mark in taking ten hour intervals between discharging as typical of decantation slime plants. From four to six hour intervals would be more correct.

The percentage of slime treated in a modern decantation plant approaches more nearly from 50—54 than 30—40. The slime from the running channel is not used for building the walls, as Mr. Newton supposes, as this material is most unsuitable for the purpose for the reasons he gives. Portions of the channels are stopped off as the level of the dam rises. These portions are filled with heavy slime, which is allowed to become partly dry and then used for building the walls. The authors cannot agree with Mr. Newton's statement that the contraction of slime in the dams during drying lessens the bursting pressure on the walls to any appreciable extent. Bursts in walls caused by pressure generally occur near the bottom. The shrinkage of slime in dams during drying is generally outwards towards the walls and not away from them, as shown by the cracks that develop.

In reply to Mr. King, the authors beg to state that although they advocate that as much of the discharging as possible from the slime plant should be done in daylight, they quite recognize the fact that it is not always possible for *all* the discharging to be done during that time. They also consider that an unstable mass, such as is contained within the walls of a slime dam, is hardly a suitable foundation on which to build a sand residue dump.

The figures given by Mr. King regarding moisture in slime dam walls are most interesting, and confirm results obtained by the authors.

Mr. Brazier advocates building the first portion of the penstock on solid ground. If possible, this is, no doubt, the better course but is not always feasible when it is desired to gravitate solution towards a given point by means of a trench of heavy slime, as mentioned in the paper.

The authors are not quite clear as to the advantages to be gained by using an inclined penstock in preference to an "L" shaped launder. If, for example, the inclined penstock were to give way somewhere near the bottom of the dam a new penstock leading over the wall would have to be installed as would also be the case if an "L" launder were used.

The method of supporting the slats in position, as described by Mr. Brazier, is certainly better than that given in the paper.

The use of an inside channel for discharging at night has much to recommend it when the extra labour required to build and maintain an extra wall can be afforded.

Mr. Fraser Alexander's contention that the selection of a site on which to build slime dams is of paramount importance is, no doubt, correct, but, unfortunately, this selection is very frequently limited to that known as "Hobson's Choice."

The thanks of the authors are due to Mr. Alexander for his definition of slime, although they cannot quite understand why the gold has to be extracted before this material can fall under the designation. Perhaps Mr. Alexander meant "slime residue." Mr. Alexander's remarks regarding sloppy foundations and slowly growing sand dumps are well worth remembering. His estimate of a grade of 0·8% for the channels conveying the slime is a trifle conservative. An allowance of 1% grade would probably be safer.

The contention that tarred iron pipes are superior in lasting power to wooden launders can be taken as correct. Tarring of the launders and slats adds considerably to their life.

The authors are glad to note that the "Irrigation" system of conveying slime pulp in channels made from the slime itself was used by Mr. Alexander in 1904, and can only regret that he should have kept this valuable information a profound secret for so long, thereby giving the authors the trouble of re-inventing it for themselves at a later date.

Mr. E. M. Weston's suggestions as to the use of brushwood for binding the outside walls is a useful one, but the authors are inclined to doubt if the supply of this material would be as plentiful and cheap as Mr. Weston considers it is.

The description given by Mr. O'Hara of building a slime dam at the Nigel is most interesting, and there is no doubt that a dam built in the manner described would give a maximum of safety with a minimum of trouble and maintenance.

It is unfortunate that experience gained from the breaking away of slime dams during the present unprecedented rains have not been put on record as much valuable data would have been brought to light.

In the Simmer Deep-Jupiter slime dams two washaways were caused by the exceptionally large amount of storm water collected on the surface of the dams, with which the penstocks were inadequate to cope. The breaks in the walls were made by the cutting action of the water overflowing the dam wall, and were not caused by bursting or slipping of the outside walls, and were purely local. This the authors consider was due to the method of construction, which also allowed of repairs being quickly effected without causing any delay in the operations of the slime plant. Both washaways occurred on the morning of the 15th February last during the heaviest downpour of rain that had been experienced on the property.

A LOGARITHMIC CALCULATOR.

By D. R. Robinson (Associate).

(Printed in Journal, September, 1917.)

REPLY TO DISCUSSION.

Mr. D. R. Robinson *(Associate)*: In reply to Mr. Thorlund's remarks upon the Logarithmic Calculator, there is not very much to be said.

My reason for imagining a Brunsviga-less Rand using four-figure logs. and anti-logs. was that the use of logarithms determines the position of the decimal point with absolute certainty, without the exertion of brain-power; whereas with a ten-inch slide-rule errors in this respect are liable to creep in. I have known a block to be written down as 100,000 tons instead of 10,000, afterwards passing through a course of checking; and it was only discovered when too late. Moreover, a table of four-figure logs. with anti-logs. is almost as rapid as a slide rule, especially if made with a thumb-index.

With regard to the making and use of factor tables, there is no doubt but that this method is quite satisfactory (with the exception of the vagueness of the decimal point noted above, if a slide-rule is used); but I claim that the Calculator is quite as reliable and quicker to use, and does not fall short for want of the factor T ÷ W; for this is given when the stoping width is taken as 1.

I suggest that the reading be done thus: First set all the factors as described in my notes in the September *Journal*, and note Tonnage. Secondly, holding down the first movable disc, move the stoping width index to the marked point 144, and the cursor will read Inclined Square Feet: finally, back to 1, and note T ÷ W. I am sure, if Mr. Thorlund will try this, he will find it quicker than tables.

The meeting then terminated.

Correspondence and Contributions.

Discussion will be opened at the April meeting of the Society on the following contributions.

ASSAY ECONOMICS.

In the modern up-to-date assay office there is not the same scope for economies as existed some years ago; still there are a few points which may be touched upon, from which a beneficial discussion may arise.

Litharge.—The biggest item in the aggregate of stores costs is litharge. The local manufacture of this all-important substance in gold assaying is now an accomplished fact. Many of us who believe in "parting" everything, would be glad to be provided with a cheaper brand of litharge, free from gold, but unrefined as regards silver; this might suit the manufacturers, and would be a saving to the user: cheaper litharge, and less silver to be added to a charge.

What is the Function of Litharge?—In the past a lot has been said about borax being "an effete superstition"; I now raise this question—is litharge being used for its proper function, viz., a lead producer for gathering the gold contents in a charge under fusion, or is it also being used as a flux? Litharge as a flux at 60s. to 70s. per 100 lb. is a luxury, when Soda Carbonate at 12s. 6d. per 100 lb., plus a good heat, is all that should be necessary. I have recently seen a flux for a 5 A.T. charge in which 4 A.T. litharge was used; presumably a 40 gm. button would be reduced, thus leaving 2½ A.T. litharge in the slag.

Soda Carbonate.—Locally produced carbonate of soda for assaying is also an accomplished fact. It contains, roughly, 90% Na_2CO_3, but I find an occasional sack running somewhat less than that; where strict attention is given to fluxing, this would require to be allowed for. A little more attention by the manufacturers is required for the production of a more uniform quality. I find it contains quite a quantity of very hard lumps, which will not rub through a sieve, but require breaking up in a mortar; their elimination would be a decided improvement.

As regards the price of locally produced carbonate of soda, a few years ago Brunner Mond's soda, averaging 96% to 98% pure, was obtainable locally at 8s. 6d. per 100 lb. This was a purer article, better packed, and more uniform. Surely our local people can do better for us than 12s. 6d. per 100 lb., or is this the usual war price?

Borax.—Personally, I agree with the theory that "borax is an effete superstition." If the furnaces are kept in good condition, and run at a high temperature, I have found the use of borax unnecessary, and the resulting lead button comes away cleaner and brighter from the slag.

With regard to the borax substitute on the market at present, the above being my opinion, needless to say, I am not very enthusiastic about it. On trial I could not see any improvement in my fusions, and its deleterious effect on crucibles was marked.

Crucibles.—I suppose the imported crucible is a thing of the past by now. The local crucible I have found excellent and very uniform. The quality is not quite what it was a few years ago; but still, is superior to the old imported crucible. The following are the figures for two different years in the East Rand Proprietary Mines assay office:

	Total Fusions.	Crucibles	Fusions per Crucible
1914	203,600	9,300	21·9
1917	204,200	16,280	12·5

Cupel and Cupel Powder.—For many years I have used only cupels made in my own department. They are made with a cement bottom, and cupel powder top. Roughly, two-third cement, one-third cupel powder. The cement shews a decided economy.

I still use the old swinging screw type of cupel machine, and on the whole, find it satisfactory; one boy turning out close on 20,000 cupels per month, their average cost being about 2s. per 100.

I have used both imported and local cupel powders, and on the whole prefer the local. As regards the absorption of gold in cupellation I found practically no difference. The local powder on the whole is finer ground, which to me seems an advantage, giving a finer finish to the working face of the cupel. Occasionally a drum of rather coarse material is sent out, which is somewhat silicious and not satisfactory, and on one occasion I found carbide powder present (through the drums not being cleaned out, I suppose), but fortunately this was noticed before a large number was made up. The cupels made from local powder I also found to stand handling better when dry than those made from imported powder.

With regard to the cost of cupel powder, the local manufacturer's price was always a shade below the imported material, but recently the usual "increase owing to the cost of raw material" has been put on. A little healthy opposition in the manufacture of cupels and cupel powder would be beneficial, as it is difficult to see why a cupel powder cannot be put on the market at one-half the present price, still leaving a fair commercial profit to the manufacturers.

Muffles.—There seems to be no reason why muffles should not be manufactured locally, with the same success as has attended the manufacture of crucibles and liners for smelting. At present they are all imported.

On the Rand many different sizes and types are in use, such as K., K.K., L., L.L., etc., etc. Now, with our modern coal furnaces, why not have a standard size muffle? The local manufacturers have not taken up this branch of the business, mainly on account of the varied sizes and types in use, and I understand that if a standard type was installed, they would take up the manufacture of muffles.

Muffles are expensive, and a little care with them pays. Very often they are insufficiently supported, with a consequent shortening of their life. Cracks can often be mended with a mixture of fine slag and fire-clay made into a paste with water.

I have also had false bottoms, made locally, fitted, thereby lengthening the muffle life, but more recently by giving more attention to longitudinal support, have found this unnecessary.

The average consumption in the East Rand Proprietary Mine assay office for 17,000 to 20,000 cupellations per month is four L.L. muffles.

Silver.—All silver used should be reprecipitated and recovered; by flattening and rolling into thin strips it can be used over and over again, a small additional amount monthly making up the working losses. I find that the working loss on 17,000 to 20,000 partings per month averages about 3 oz. This amount about suffices to part all reduction samples, solid and solution, and is used in the form of fine silver wire.

Reducer.—Mealie-meal as supplied to the compounds I find to be an excellent substitute for charcoal or flour, and is indeed preferable as not being so powerful a reducer, a larger quantity may be used, and a more intimate mixture obtained.

Acids in Solution Assaying.—The old method of reduction and precipitation by means of sodium sulphite and copper sulphate, in a hydrochloric acid, or sulphuric acid solution may be safely abandoned for the more economical one of precipitation by means of prepared cuprous chloride.

Commercial hydrochloric acid, as manufactured by the B.S.A. Explosives Co., costing 2·1d. per lb. against 2s. 10d per lb. for the imported acid, commercial copper sulphate, and scrap copper wire, are all that is required to make cuprous chloride solution, giving instantaneous precipitation of gold from solution in the cold. With this method the use of imported hydrochloric and sulphuric acids may be dropped.

Nitric Acid.—Chemically pure nitric acid especially free from chlorine and iodine, is an essential in gold assaying. I see little prospect of its manufacture locally, unless the B.S.A. Explosives Co. take it up. Something might be done by economising somewhat in its use. Keep the quantity used in parting as small as possible—a big excess is always used, probably a hundred times more than is theoretically necessary for the average small beads—by keeping the quantity for a parting as small as is practicable a slight economy might ensue. Then in bullion parting, the strong acid from to-day's bullions can be diluted down for to-morrow's 1st weak acid, with considerable advantage.

Apparatus.—There is not much scope for economy in apparatus. The ordinary clear glass household water jug, quart capacity, can replace large beakers or flasks for solution assays. Where boys do the washing up, this will be found an economy. Then clear glass, quart size, whisky bottles are convenient for filtering into, saving filter stands and flasks. Train boys to fold filter papers, and use a cheap grade of filter paper, one that filters solutions clearly is all that is necessary.

Many other points must occur to routine assayers. It is to be hoped they will send along their ideas, and help the community at large. Every ton of economy is a ton of shipping reserved for something which cannot be done without.

CHRIS. TOOMBS.

ASSAY REQUISITES.

Having been requested to contribute a short article dealing with the above, the writer gives his own experiences and hopes that other assayers will contribute to the discussion of this subject under "General Business," at the next monthly meeting.

Crucibles. — For assay work we use entirely Transvaal made pots (link shape, sizes 1, 3 and 5). For the last seven or eight years these have been, on the whole, of very good quality. Plumbago, or salamander pots for smelting gold can now be ordered from a Boksburg firm. So far we have not had an opportunity of testing these, and are still using the Battersea brand.

Muffles. — The "Rival" assay furnace, here, takes four of "K" size. In 1912 the writer had a muffle of this size (made by a Boksburg firm) sent for trial. It was tried and found equal to the Battersea make; but, for some unknown reason, we have not been able to get any more of local make, and are using imported fireclay muffles.

Cupels. — Previous to the South African war (1899-1902) bone-ash was used by all assayers, some buying cupels made in France or London, others making their own (chiefly by hand) from imported bone-ash. The writer knew one assayer, even in those days, who prepared his own bone-ash from old bones, collected by his assay natives on the veld. From 1902, "mabor," "morganite," and "cupellite" came into use.

Just two years ago, the City & Suburban G.M. & E. Co., installed a machine for making cupels, using compressed air. The model was similar to that perfected by Mr. Otto, chief assayer on the Geldenhuis Deep. As the air-pressure available on the City and Suburban was some 20 lb. less than that used at Geldenhuis, our engineer (Mr. Tregaskis) had the air-piston made of slightly larger diameter.

This machine has worked well, and one assay native, in his spare time, can make all the cupels we require. We have three different sizes of cupel moulds, these can be changed (in about 15 minutes), say, every five or six days. The material used is "cupellite," prepared locally, which we buy at 50s. per 100 lb. drum: this quantity will make over £5 worth of cupels.

Cement for Cupels. — Some of the mines on the Reef have used a cupel, the lower part (about ¾) of which is made of cement and the upper quarter or "cap" of "mabor" or "cupellite." When we first installed our machine we made several hundreds of these, using White's Portland cement and a "cap" of "mabor," and we gave them a trial on mine sample assays. Our experience showed that about 20% to 25% of these assays had to be repeated, owing to the upper part of the cupels cracking or collapsing. In other cases, scorification of the auriferous lead bead had taken place. Finally, we got so disgusted with these three-quarter cement cupels that we sent some hundreds of them away, with old cupels to the cyanide department for making "tests." The chief object of the assayer should be to obtain, in all cases, an accurate and true result; low working costs should be quite a secondary consideration.

Mr. Otto, at Geldenhuis, told me that although he had made and used many thousands of cement cupels (as above) with mabor cap, yet they were nothing like so satisfactory as cupels made entirely of mabor.

Slag Absorbent and Muffelite. — The magnesite from Barberton district, after calcination, pulverising and sieving, answers very well for these purposes. The coarser grading should be used for the furnace-bed and the finer for the muffles. These, again, take the place of bone-ash which was formerly used.

Litharge. — The "Acme" brand from New Clare is now obtainable. We have used several drums, always checking in duplicate, for silver and gold content, before use. So far, we have not found any gold in this brand of litharge and the silver was 0·3 dwt. in the flux required for 1 assay ton of ore.

Soda Carbonate. — For some years we have been using the South African Alkali Co.'s product, supplied in bags, for assay work. A while back some of the bags had, apparently, got wet and the soda had caked in hard lumps.

It is well, also, to estimate the chloride in this brand from time to time, as this may vary considerably.

Fluor Spar or Borax. — We tried to substitute pulverised fluor spar for about half of the borax used in our assay flux. It was tried in various proportions. The melting point of calcium fluoride (1,330° C.) is very much higher than that of borax, and we found that the substitution of fluor-spar, caused, in many cases, the charges to froth-up, boil over, and give consequent low assay results. The writer cannot therefore recommend fluor spar for assay work.

Last July we were circularised by the Corner House metallurgical department on this subject, and made a series of check assays; also, the circular was shown to our cyanide foreman (Mr. Murdoch), who tried fluoride for his smelting in the reverberatory furnace. He reports: "50% of the borax formerly used is replaced by the fluor spar. The slag is fluid, the buttons clean, and the gold bullion obtained is good. A tendency to boil-over when putting the cold pots into a hot furnace is guarded against by not filling too full. The saving on borax at its present price amounts to £17 a month."

Commercial Hydrochloric Acid is now, I understand, being made in the Transvaal. This should supply local plumbers with "spirits of salt," and it is also useful for generating gases, cleaning bottles, etc., in laboratories.

Ammonia.—It is interesting to learn that a Johannesburg company has succeeded in producing Liq. Ammon. Fort. (Spec. Grav. 0·880). It may be added that all the raw materials employed are South African products. For this information we are indebted to the *South African Journal of Industries*, No. 6, *i.e.*, the February number. It is hoped that our members will support this new and interesting Government journal, the price of which is only sixpence monthly.

John Watson.

23rd March, 1918.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Determination of Tungsten.—"To 1 gm. of the finely powdered wolfram in a 250 cc. beaker add 10 cc. concentrated HCl, and agitate carefully to prevent caking. Add about 80 cc. more of HCl, cover with a watch glass and boil until the volume of acid is reduced to about 5 cc.: cool, add 5 cc. concentrated HNO_3, and digest at nearly a boiling point temperature for 5 to 10 minutes, dilute to about 100 cc. with H_2O, let settle, and filter through a 9 cm. paper, wash with H_2O transferring as little WO_3 as possible to the filter. To the beaker add about 10 cc. of H_2O and then portionwise (down the sides of the beaker) 10 cc. of dilute NH_4OH. With a rubber-tipped rod remove any deposit from the sides of the beaker into the alkaline solution, heat to boiling, and stir well. If the suspended matter does not readily subside, boil again until the desired result is attained; let settle, filter hot through the original paper into a 250 cc. flask, wash two or three times by decantation and complete the washing of the paper. Reserve the cover glass, filter paper, and beaker. Evaporate the NH_4 tungstate solution in the flask to a small volume, transfer to a weighed Pt dish, evaporate to dryness on steam-bath, ignite gently then strongly, weigh as WO_3. To the beaker containing the heavy residues add 5 cc. of HCl, cover with original watch glass, and boil till nearly dry; add a few cc. of HNO_3 and heat 10 minutes, dilute with H_2O, let settle, filter through a small paper, and wash the beaker and paper several times. Wash the filter paper, also the original filter paper, with a little hot dilute NaOH solution, followed by small washes of H_2O, and collect the alkaline liquors and washings in a beaker. If the watch glass is stained with WO_3, dissolve with a few drops of the NaOH solution and add to the contents of the beaker. Heat the contents of the beaker to boiling, add about 2 gm. of NH_4NO_3, and stir well while boiling; filter through one of the papers previously used, and wash a little. Nearly neutralize the filtrate with dilute HNO_3, add a few cc. of $HgNO_3$ solution, stir well, filter on a small ashless paper, wash, ignite, and weigh as WO_3. Add this weight to the weight of the WO_3 in the Pt dish. Fine grinding is essential. With experience 2·5 gm. of sample may be taken without requiring any modification of the quantities given above. The complete decomposition with the boiling HCl requires about 1 hour."—H. W. Hutchin, *Mining Mag.*, *1917*, Aug.: *Mining Sci. Press*, *115*, 389 (1917).—*Chemical Abstracts*, Dec. 10, 1917, p. 3186. (J. G.)

Separation of Antimony and Tin in Hydrochloric Acid Solution.—"The concentration of the HCl solution must be adhered to rigidly. Placed the mixed solution in a 300—350 cc. Erlenmeyer flask, add 60 cc. HCl (d. 1·19), make up the volume to 200 cc., heat to the b.p. and pass a rapid current of H_2S for 10 minutes, then a slow current while the solution cools to room temperature. Filter off the Sb_2S_3, wash with H_2S solution containing 60 cc. HCl (d. 1·19) in 200 cc., and finally with H_2O. Collect the filtrate in a 250 cc. flask, make up the to the mark and mix at once. Return the Sb_2S_3 to the precipitation flask and dissolve by boiling with 20—5 cc. HCl and an equal volume of H_2O, with a funnel placed in the neck of the flask. Add 30—40 cc. H_2O, and boil 10 minutes, cool, add 2 drops of phenolphthalein solution and 2—3 gm. Rochelle salt, then a slight excess of NaOH solution. Then acidify slightly with HCl and add 20—5 cc. of a saturated solution of $NaHCO_3$ and titrate with an I solution standardized against pure tartar emetic. To determine the Sn add to 100 cc. of the filtrate from the Sb_2S_3 50 cc. H_2O and 2—3 gm. Fe powder or wire, close the flask with the stopper carrying a tube dipping into NaOH solution, boil till the H_2S is driven off and the Sn reduced, replace the NaOH solution with one of $NaHCO_3$ and allow the Sn solution to cool with exclusion of air. Then add 100 cc. of air-free H_2O and starch solution and titrate with an I solution standardized against a similarly prepared Sn solution."—A. Prim. *Chem. Ztg., 41*, 414-5 (1917); *J. Soc. Chem. Ind., 36*, 737; *Chemical Abstracts*, Dec. 10, 1917, p. 3189. (J. G.)

MINING.

Mechanical Ventilation of Metal Mines.—Mechanically produced ventilation of mines has been regarded, until the last few years, as necessary only in coal properties. The haphazard ventilation of metal mines is in striking contrast to the high order of engineering in other departments of metal mining operation. Ventilation of coal mines, on account of the inflammable gases given off from the strata, or because of the loss of oxygen from the air through absorption by the coal, made the positive 'coursing' or circuiting of the air current a necessity. This was recognised a century ago after serious explosions of fire-damp had occurred, although coal-mining operations were on a very small scale at that time. Notwithstanding the slow development of positive ventilation in metal-mining operations, mechanically produced ventilation of such mines received an early start. Agricola in his book describing the mining practice of the 16th century in the Harz mountains repeatedly refers to ventilation. The following are some quotations taken from the Hoover translation of Agricola's book:

'I will now speak of ventilating machines. If a shaft is very deep and no tunnel reaches to it, or no drift from another shaft connects with it, or when a tunnel is of great length and no shaft reaches to it, then the air does not replenish itself. In such a case it weighs heavily on the miners, causing them to breathe with difficulty, and sometimes they are suffocated, and burning lamps are also extinguished. There is, therefore, a necessity for machines * * * which enable the miners to breathe easily and carry on their work.

'These devices are of three genera: The first receives and diverts into the shaft the blowing of the wind. * * * The second genus of blowing machine is made with fans, and is likewise varied and of many forms, for the fans are either fitted to a windlass barrel or to an axle. * * * Blowing machines of the third genus, which are no less varied and of no fewer forms than those of the second genus, are made with bellows, for by its blasts the shafts and tunnels are not only furnished with air through conduits or pipes, but they can also be cleared by suction of their heavy and pestilential vapours.'

Agricola's drawings show many varieties of ventilating devices; some are dependent, as indicated in the above quotation, on the effect of the wind, while others are the predecessors of the centrifugal fans. Several of the drawings show large feathers set radially in the axle; others show wooden blades or paddles arranged as in the later Guibal fan. Apparently, however, the proper arrangement for admitting the air to the fan at the axle had not then been discovered. In these old drawings, the air appears to enter a slot on the circumference of the casing and is discharged through a wooden conduit at another place on the circumference. Presumably the action of the fan was improved through the leakage of the wooden sides, so that accidentally it may not have been as inefficient as it appears. The drawings seem to indicate that the use of brattices in shafts and ventilating doors was understood, although there is no indication that a circuit of air was maintained, away from the shaft or beyond where a shaft intersected drift-workings, except by wooden pipes.

Little advance seems to have been made in metal-mining ventilation for the 300 years thereafter, until compressed-air drills came into use; then the exhaust was regarded as furnishing sufficient air in the working place. When the drill is not running, if the atmosphere is oppressive in the heading or stope, or is foul after blasting, the compressed air is allowed to blow direct from a pipe outlet. Undoubtedly in small metal mines, or those in which there is no considerable amount of noxious gas given off, or where workings are a short distance from the drift-mouth or shaft, this may be sufficient. In most metal mines, owing to the ore formation generally having considerable length along the strike, and depth vertically or on the dip, but generally no great width, the difference in temperature between the lower workings and the outside atmosphere generates air-currents when secondary connections have been made to the surface.

Inflammable gases are rarely found in metal mines, and generally there is a little absorption of oxygen by the ore or enclosing walls, although in mines in which there is much timbering it has been found that there is considerable absorption of oxygen by the timbers due to bacteriological action. Nevertheless, thousands of samples of air that have been gathered by the Bureau of Mines in metal mines indicate that, except after blasting, it is rare when the air contains a considerable amount of impurity. Occasionally, as in the Cripple Creek district, metal mines contain large amounts of pure nitrogen gas residual in the strata. Such mines can only be worked by the employment of a plenum-pressure system of ventilation. In general, however, the chief air impurities in metal mines arise from blasting.

In the case of long drainage tunnels, the rule is to ventilate with fans and air-pipes, and it is obvious that it is economic advantage to quickly ventilate the heading after blasting so that the miners may get back to their work as soon as possible.

In great orebodies, such as are found at Butte, in the Lake Superior iron and copper mines, in the copper mines of the South West, and especially in the deep and extensive gold mines of South Africa, there has been a gradual introduction of mechanical ventilation apart from any dependence on compressed air at the faces.

Attempting to ventilate by means of compressed air when there is a considerable volume of noxious or poisonous gases present, as from blasting, is extremely inefficient both in sweeping away the smoke and gases which it tends merely to stir up, and from the important standpoint of mechanical efficiency in using air which is usually compressed uneconomically to a high pressure, and liberating it without doing mechanical work against atmospheric pressure. The only remedy is to arrange as far as possible for circuiting of the air, supplemented by 'booster' fans.

It is hardly worth while to argue the need of having two means of exit from a mine, as this is the requirement in most State metal-mining laws. Probably over 95% of the metal mines of the country which have reached a permanent basis of ore production, have two exits. Where there are two such exits one naturally becomes the up-cast and the other the down-cast. Unfortunately, however, these conditions sometimes change with the season and with such changes the natural ventilation underground is insufficient. Hence there is necessity for the use of fans. In very deep mines, such as in the copper mines of the Lake Superior district, normally the up-cast and down-cast conditions do not reverse, and the natural main up-casting current is very strong. It then becomes a problem whether or not in the interest of safety to prevent reversal of the current in the case of a mine-fire in the down-cast, it is not best to install a large fan, which may never be needed except for fire-protection. However, in the great majority of mines a strong non-reversing current due to the difference in temperature in the up-cast and down-cast shafts cannot be obtained. This being the case it is highly important, both for fire-protection and for a positive circuit of air through the mines that fans shall be used.

The great variety of conditions found in metal mining in the United States, varying from typical veins to the great lenticular and irregular iron-ore deposits of the Lake Superior district, makes it impossible to lay down as exact a procedure as is usually regarded necessary in planning coal-mining development. Nevertheless it will be generally conceded that a great deal more might be done in the future than in the past if preliminary planning of a ventilating system is borne in mind, particularly in developing low-grade deposits.

While metal-mining laws and modern practice require two exits and recognise the necessity of air down-easting in one shaft or winze, and returning through another shaft or winze, adit, or tunnel, the necessity for provisions for circulating the air through the mine has not been well recognised, with the result that in some of the great mines of the United States the ventilation is of the most haphazard character. Often I have had occasion to observe that the main fan placed underground is ineffective because part of the air-discharge has been circuited round and round. Therefore, even when the percentage of impurity in the air might be low it did not take care of one of the most important features of deep mine ventilation, namely, to keep the temperature below that of the mine-walls. It is not always a question of depth or natural heat of the strata, but where large masses of timber are employed, especially in the caving-system employing a timber-mat, the temperature is frequently far greater immediately under the mat than it is in the deeper levels.

It is believed that if the same degree of care were taken in laying out in advance the ventilating system that is given to laying out the levels, drifts, cross-cuts, and raises, for extracting the orebody, a great deal of the difficulty of a physiological nature now experienced by the miners would be prevented. These troubles are not simply those of temporary discomfort of the workers, but their health is likely to be affected, making them liable to contract diseases, lessening their working efficiency, and thus decreasing the earning power of the mine. Ventilation therefore comes to be a matter of economic importance. It is difficult to speak of specific mines or districts without making unfortunate comparisons, but that the problem is acute will be readily admitted by most mining authorities.

Another phase of the physiological problem concerning workers in hot mines, is not alone in the high temperature of the air but in the fact that the air is not in motion. The experiments of Dr. Haldane, of Oxford, the celebrated physiologist, brought out strikingly that in still hot air the body is enveloped with a film of air at or near the blood-heat and the skin is not cooled by evaporation of the sweat, but if the air is in motion, unless it is saturated, which it seldom is, evaporation follows, and thus the skin is cooled. I recall a case where, in a certain stope, there was no movement of the air, and the miners complained of the heat and from time to time went into a nearby cross-cut where there was a strong current of air and were comfortable, although in the cross-cut the temperature was actually several degrees hotter.

The great variety of mining conditions found in the United States prevents formulating an exact specification for a ventilating scheme which would fit all conditions, but in order to bring out discussion the following general principles are mentioned which may be of guidance in planning a ventilating system for new mines or in adapting the arrangement of old mines as far as possible :

(1) There shall be a permanent up-cast and permanent down-cast shaft.

(2) The down-cast shaft shall be, as far as practicable, the shaft in which the men are hoisted and lowered. It may or may not be the main ore-hoisting shaft, the object being that, in case of fire, the main hoisting arrangements for the men will be available, and, if practicable, this shaft and its landing shall be concreted or otherwise fire-proofed, and back of each landing there shall be a fire-proof door to protect the men from the workings beyond.

(3) The main shaft shall extend to the lowest working so that the fresh air may go to the bottom of the mine and then ascend on either side through the workings to the up-cast shaft ; sufficient splits of air to be taken off on the different levels to provide for proper ventilation ; the return air to be taken around the down-cast shaft by cross-cuts or concreted bridges.

(4) The main ventilating fan should be placed on the surface ; the fan to be of fire-proof construction and with fire-proof housing ; this to be a reversible fan. Generally the most convenient arrangement would be to place it near the collar of that shaft which is not the main hoisting shaft. Of course a tunnel or slope mouth would be equally as good. This is to avoid an air-lock ; therefore, the fan would normally be an exhaust-fan, but as previously stated it should be reversible to provide for emergencies.

(5) The fan should be of sufficiently large size to take care of the largest volume of air which is likely to be necessary for at least five or six years of development, and it should be able to deliver and to draw air at a pressure in excess of that which could be produced by maximum natural causes, that is, the maximum motive head of the air column, due to the maximum difference which may obtain, between the temperature of the mine-air and of the outside air, in the coldest or the warmest days of the year. In general, the main fans at metal mines are entirely inadequate, and fans such as are employed in large coal mines should be installed in metal mines where the workings are expected to be of large extent and to require many men underground. By this is meant fans which will discharge from 100,000 to 300,000 cub. ft. of air per minute against a pressure measured by 2 in. to 6 in. of water gauge. On account of the fire-risk it is not good practice to place the main fan underground, and moreover there is usually a liability of the air short-circuiting, that is, going around and around and not being discharged to the surface.

(6) 'Booster' fans are necessary in exploratory drifts, and in running winzes or raises and in high stopes. New devices in the way of canvas pipes and hanging arrangements have been developed recently that make admirable auxiliaries for reaching the face of headings and winzes, but wherever possible it should be planned, as in coal mining, that a continuous circuit of air be obtained after it has been established that bodies of ore exist that sooner or later will have to be blocked in order to give adequate ventilation throughout.

A number of the greatest fire disasters in metal mines would have occasioned a much lower loss of life had there been continuous circuits of air, which would have enabled the miners to reach the in-taking air. The great merit in fire-proof down-cast shafts and the landings adjacent to these is to enable the escape of the men who could keep in fresh air by travelling against the in-taking current. On the other hand, if an unfire-proofed down-cast takes fire, as at the Cherry coal mine or the North Butte copper mines, it nearly always means disaster, and the only remedy then is a prompt reversal of the fan, which if accomplished in time might save the men. If this cannot be done, or if all passages for escape are already filled with smoke, the only thing left for the men is to brattice or bulkhead themselves off in some heading free from smoke, marking with chalk where they have gone, for the subsequent direction of the rescue parties. While the cost of providing adequate ventilation is considerable, whether it be in metal mines or in coal mines, it must be regarded as a vital necessity for deep mining. Anyone who has visited deep or hot mines, such as those of the Comstock Lode or at Butte, must realise the need of providing the best ventilating system possible in order that deep mining may be carried on at all. Where nitrogen gas is found, or where spontaneous fires occur in rich sulphide ores, as in some Montana and Arizona mines, or in mines where sand or slime filling cannot be accomplished, it is necessary to erect fire-walls and put in a plenum pressure system of ventilation so that the gases may be forced back into the crevices in the strata or behind the fire walls."—GEORGE RICE. *Mining and Scientific Press*, October 20, 1917, pp. 579-581. (H. R. A.)

RESISTANCE OF ARTIFICIAL MINE-ROOF SUPPORTS.—"The purpose of this paper is to make public record of new information in regard to the sustaining power of artificial mine-roof supports (not timber props) the result of investigations recently made in the anthracite coal fields of Pennsylvania.

First. By the 'Scranton Mine Cave Commission,' appointed to investigate the mining conditions under the City of Scranton.

Second.—By the 'Pennsylvania Mine Cave Commission,' appointed by the Governor to investigate the general subject of mine caves in the anthracite region of Pennsylvania.

Third.—By the personal researches and tests made by the author in an effort to secure a better artificial mine-roof or surface support.

During the progress of the work of the Scranton Mine Cave Commission, the engineers of the Commission, Messrs. Conner and Griffith, being aware of the general lack of exact information in the engineering profession as to the strength of the ordinary artificial mine-roof or surface support, and particularly the stronger kinds, such as mine cogs, rock piers, etc., had tests made at the Fritz Engineering Laboratory at Lehigh University, to determine the sustaining power under various compressions of the several kinds of artificial mine supports in use in the anthracite region of Pennsylvania. A report of these tests was included in the report of this Commission, which was published as *Bulletin* No. 25 of the United States Bureau of Mines, Washington.

A similar series of tests, more extensive and more elaborately planned, were subsequently made for the Pennsylvania Mine Cave Commission at the U.S. Government Testing Laboratory at Pittsburgh, Pa. The report of this Commission was made to the Governor, but has not yet been published.

The author, during his connection with the Scranton Mine Cave Commission, observed that of all the various devices employed for sustaining the roof of coal mines, the one universally used and the best known—the 'timber cog,' consisting of a cribwork of logs filled with mine rock and rubbish—was possessed of comparatively small resistance under the initial pressure, but withal was exceedingly elastic, its sustaining power increasing rapidly under compression. Such cogs or cribs would not fail completely until the compression amounted to one-third or one-half the original height of the structure.

The kind of roof support that seemed to have the greatest initial resistance was found to be concrete piers, which, although somewhat costly, are nevertheless used to a small extent in some portions of the anthracite region; but the tests showed that such rigid piers would fail completely when the load upon them was sufficient to cause a compression of about 3% of the total height, and that this failure of concrete piers under pressure was sudden and without warning, thus being a menace to the safety of the miners.

It was desirable, therefore, if possible, to devise some sort of artificial roof support which would partake of both the elasticity of the timber cog and the rigidity of the concrete pier, and the author tested a number of devices in an effort to accomplish this end. The result of this series of tests was the production of what is referred to in this paper as 'Griffith's Mine Pier,' which consists essentially of a timber crib, each element or member of which is provided with a series of notches, and which may be framed in quantity, by machinery, and creosoted outside of the mine, so that the crib may be easily erected inside, the members fitting together one upon the other and forming a rigid cribwork. Concrete is poured into this crib, thus forming an artificial mine pier of simple construction, yet having an initial resistance equal to a concrete pier of the same dimensions, but which is so elastic that it will not fail under pressure until the total compression amounts to nearly 15% of the original height and the ultimate load sustained is equal to about three times the ultimate strength of concrete piers of the same dimensions, and about 20 times the resistance of the well built timber cog. We have thus produced a concrete pier reinforced with notched timbers, in the manner described.

The variety of concrete proved by the tests to be most efficient seems to be the cheapest mixture that can be made, viz., cyclopean concrete composed of pieces of mine rock as large as can be conveniently handled by one or two men; the interstices between these pieces of rock being filled with ordinary concrete grouting composed of cement, sand and small broken stone, the object being to secure the greatest density possible. In preparing the crib mentioned, the notches in the timber should be of sufficient depth—that is, nearly one-fourth the thickness of the timber—so that when the crib is finished the timbers will be separated by a space of about 1 in. or less. This permits the grout to flow in and partly fill the space between the timbers during the course of construction. After the structure is completed the unfilled spaces may be pointed with a trowel, from the outside, after which the outside of the pier may be coated with cement by the use of a cement gun or any other device.

It will be impracticable to build such a crib tight against mine roof. There will be a small space which should be filled by ramming with dry concrete; that is, concrete mixed with a small proportion of water. Thus will be formed a very lasting mine pier, because each timber will be surrounded or embedded in concrete, and if the timbers are first creosoted the construction should be very durable.

In nearly all cases, it was found that there was an elasticity of about 3% in the pier when the load was removed. In other words, the height of a tested piece, after the load was removed, was about 3% more than the height under greatest pressure. Some of the piers were tested the second time and sustained the same weight, under the compression, as in the first test.

There are many localities and circumstances in coal and metal mines where strong, elastic roof supports of this sort would be exceedingly useful, and the cost of placing the same for such emergencies would not be excessive.

Since it is a practical impossibility to introduce artificial roof support in a mine in such a manner as to prevent minute subsidence, it is necessary to assume a certain amount of surface settlement as permissible." The paper is accompanied by several illustrations graphs and tables.—William Griffith, C.E., Scranton, Pa. (St. Louis Meeting, 1917), *Trans. Am. Inst. M.E.*, pp.1797-1803. (H. R. A.)

MISCELLANEOUS.

The Value and Importance of Physical Exercises from a National Standpoint. — "A nation's welfare depends upon the mental and physical efficiency of its citizens. The evolution of the human race has shown the importance of physical efficiency. Games and sports, valuable in their way, do not take the place of skilled instruction in physical exercises. It is one of the faults of our system of education not to sufficiently recognise the fact that mental development and bodily fitness are interdependent. If our universities would recognise physical training as an integral part of the undergraduate's curriculum the status of physical culture would be enhanced. In America the universities have done much for physical training and there are elaborate and successful arrangements in vogue at such universities as Harvard, Pennsylvania, etc., for the physical education of their undergraduates. Regular instruction in physical culture has been successfully carried out for years past in Germany, Scandinavia, Denmark, and other European countries.

The physical training in our public elementary schools gives excellent results, but unfortunately ceases too early in a child's life. Only a small proportion of boys and girls go on to the secondary schools, and the majority go out into the world too soon, from a physical point of view, in order to become wage earners. It should be made compulsory for every one to continue some standard system of physical training until, say, the age of 18. The time appears to have arrived when the Government, through a Ministry of Health, should have pressure brought to bear on it to face seriously the problem of the physical fitness of the people. With a falling birth rate, a heavy child mortality, and the havoc wrought among our young men as the result of the war, the country is in danger if efficient means are neglected to rear physically fit boys and girls, the future fathers and mothers of England.

That the tide of opinion is already turning may be judged from the recent deliberations of the Labour Party upon the programme of future education when *inter alia* certain resolutions were adopted *re* swimming baths, gymnasia, and the best known scheme of physical training, etc. The following suggestions were offered by the writer of the paper for discussion :—

(1) The establishment of a central anthropometric bureau for the recording of the height, weight, muscular development, etc., of the youth of the country, such general statistics being the best criterion of the physical degeneration or otherwise of the population.

(2) Compulsory drill for two hours a week in all primary and secondary schools, public schools, and universities.

(3) The provision by local authorities of open spaces and gymnasia for drilling purposes and games.

(4) The provision of competent instructors, male and female.

The provision of open spaces for drill is essential, and if the co-operation of the municipalities could be enlisted, and the right to drill in public parks granted, there seems no reason why systematic drilling on a large scale should not be begun at once. The statistics gathered by The Metropolitan Public Gardens Association show a very healthy and growing recognition of the value of open spaces in our large centres of population. Could we not induce our municipalities to earmark certain portions of the public parks and open spaces under their control as 'Municipal training grounds,' to which the children, the young adults, and young men and women up to the age of 18, could be sent for exercise and instruction under the supervision of municipal instructors responsible to the Local Education Committee.

By a process of devolution each county might be made responsible to a central authority in London for the physical education of its inhabitants, careful annual statistics being prepared by a central anthropometric bureau showing the physical development, height, weight, muscular strength, etc., of those subjected to whatever system of national training may in the future be adopted.

To our detriment we have no purely British system of physical culture—comparable to Swedish drill, German gymnastics, or American games—nothing, in fact, branded with national characteristics."—Major Sir Wm. Milligan.—*Chemical News*, July 13, 1917, p. 18. (J. W.)

Abstracts of Patent Applications.

39.17. Charles Edward Meyer. Improvements in or relating to the treatment of zinc-gold slime, and in apparatus for use in connection therewith. 5.2.17.

This application relates to the treatment of zinc-gold slimes resulting from the cyanide process of extracting gold from its ores. It includes both the process and apparatus for carrying out the same. The main object of the process is to recover certain of the materials used during precipitation of the gold, and also the solvent used in the refining process preparatory to smelting.

74.17. Lewis Condict Bayles. Improvements in fluid operated percussive tools. 26.2.17.

This application refers to a fluid operated percussive tool consisting of a cylinder having a larger forward bore and a smaller rearward bore, a piston having a head in said forward bore and a shank in said rearward bore, with a neck between said head and shank, a fluid passage for admitting fluid constantly to the rear end of said smaller bore, fluid passages controlled by the piston for alternately admitting fluid to the ends of said forward bore, exhaust passages for the ends of said forward bore and valve mechanism for opening and closing said exhaust passages.

There are five other claims, which are elaborations of the principle set forth in the first claim.

95.17. Harry Newbery. Improvements in over winding prevention devices. 12.3.17.

The application relates to a device for the prevention of overwinding in mine hoisting operations. The chief feature consists of two relays placed in such a position relative to one another, that only one can be operated at a time. By these means, in conjunction with the ordinary mine signal system, in which there are separate bells for men and rock hoisting, safety devices are automatically brought into operation either for men or rock hoisting, according to which bell is rung.

582.17. Sopwith Aviation Company, Limited (1), L. J. P. Fowler (2), H. A. Kamper (9). Improvements in fluid pressure relieving devices. 2.10.17.

This application refers to a fluid pressure relieving device, comprising a casing, flexible diaphragm, dividing said casing into two compartments, one of which has two ports or passages and one of which is in free communication with the receptacle containing the fluid under pressure and the other of which is open to the atmosphere or to a separate receptacle, a valve closing the said latter port or passage, a spring operating to lift said valve, a plunger mounted in a cylindrical guide in the other of the two compartments of the casing and adapted to contact the flexible diaphragm immediately above the valve, a spring operating to exert pressure on said plunger to depress the flexible diaphragm, and means for regulating the strength of said spring.

604.17. Chas. Wright. Improvements in ventilators. 8.10.17.

This application has reference to improvements of ventilators, such as are used in buildings or on ships.

591.17. Arthur Edwin Leigh Scanes. Improvements in vacuum ejector apparatus. 3.10.17.

This claim is for maintaining the vacuum in a steam condenser, evaporating plant or the like; an ejector apparatus in which the air, gas, or vapour to be removed is first compressed by said ejector the working medium of which is air admitted to the ejector nozzle from the atmosphere, the air, gas, or vapour thus compressed, and the air passing through said nozzle finally expelled by a steam ejector.

661.17. John Marriott Draper. Improvements in apparatus for separating substances of different specific gravities, such as fine coal or ores and the like. 29.10.17.

This application is for a hydraulic classifying device in which, in addition to the ordinary pressure water to the sorting columns, a further water service at a lower point in the sorting column is attached, fed from a vat whose water-level corresponds with the overflow of the receptacle. Where the apparatus is used for the separation of coarse material, prohibiting the use of a reducing nozzle, a closed collecting chamber is attached provided with suitable elevator working in a tube, the water level in which is maintained at the level of the overflow and balancing vat.

767.17. Henry Livingstone Sulman (1), Edwin Edser (2). Improvements in or relating to the concentration of ores. 10.12.17.

This application is for means of concentrating ores by flotation methods, in which the mineral content is partly or wholly oxidised, and consists in substituting soluble soap in a neutral or alkaline circuit, for the usual oil and acid. Further, in adding to the circuit a small proportion of a substance which causes the gangue material to be wetted by the water but does not decompose soap, such as sodium silicate, silicic acid, "sol," etc.

831.17. The Salt Union, Limited. Improvements in or relating to the working of gas producers. 28.12.17.

This application relates to improvements in the working of gas producers. The improvements consist of mixing lime with coal, particularly bituminous or caking fuels by which the ammonia is increased and the tendency of the coal to cake prevented. This has been known for many years in gas making.

Changes of Address

Blyth, W. B., *L/o* Bulawayo: P.O. Box 1, Salisbury, Rhodesia.

Candy, H. S., *L/o* Johannesburg: P.O. Box 5, Millsite.

Exten, J. K., *L/o* Brakpan: Messina Mine, Northern Transvaal. (*On Active Service.*)

Gow, G. Aubrey, *L/o* Benkoelen: 17, Hawkestone Street, Wellington, New Zealand. (*On Active Service.*)

Morse, W. S., *L/o* Delaware: 120, Broadway, New York, U.S.A.

Schoch, E. B., *L/o* Rooiberg: P.O. Box 2927, Johannesburg.

Silverley, H., *L/o* Piggs Peak: Mount Morgan Mine, Barberton.

Thorburn, J. M., *L/o* Selukwe: P.O. Box 1214, Johannesburg.

APR 1 , 1920
UNIVERSITY OF T

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII APRIL 1918. No 10.

Proceedings
AT
Ordinary General Meeting, April 20th, 1918.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 20th April, 1918, Mr. A. Whitby (Vice-President) in the chair. There were also present:—

28 Members: Messrs. H. S. Meyer, H. A. White, H. R. Adam, J. Chilton, F. G. Macdonald, C. Toombs, F. W. Watson, John Watson, E. M. Weston, Profs. G. H. Stanley and J. A. Wilkinson (Members of Council), P. Carter, J. M. Dixon, N. M. Galbraith, C. J. Gray, C. H. Greathead, N. H. Griffin, T. Little, C. A. Meiklejohn, E. C. J. Meyer, H. H. Morrell, P. T. Morrisby, S. Newton, J. F. Pyles, J. Thorlund, I. Tom, G. A. Watermeyer.

9 Associates: Messrs. J. Cronin, J. Davidson, O. A. Gerber, J. Gibson, J. Innes, J. S. Moir, D. W. Pugh, J. Whitehouse, J. A. Woodburn.

7 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 16th March, 1918, as recorded in the March *Journal*, were confirmed.

ELECTION OF NEW MEMBERS.

Prof. J. A. Wilkinson and Mr. H. A. White were elected scrutineers, and after their scrutiny of the ballot papers, the Chairman declared the following gentlemen unanimously elected to membership:

Bagley, Allan, B.Sc.(Wales), F.I.C., P.O. Box 2724, Johannesburg. Analytical Chemist.

Johnson, John Pratt, M.B., B.S.(Lond.), D.P.H. (Oxon.), 139, De Korte Street, Wanderers View, Johannesburg. Medical Practitioner and Bacteriologist.

The Secretary announced that the following gentleman had been admitted by the Council as an Associate:—

Wood, John, Durban Roodepoort G.M. Co., Ltd., P.O. Box 111, Roodepoort. Assayer

General Business.

THE AMERICAN RED CROSS MISSION TO PALESTINE.

The Chairman: I would like to extend a very hearty welcome to Capt. Carson, who is a member of the American Red Cross Mission to Palestine, which is in South Africa, *en route*. Capt. Carson, who is an engineer, will be able to give us some recent news of American affairs as they relate to the war, and may possibly be able to tell us what work the Mission, of which he is a member, proposes to undertake in the Holy Land.

Captain Harry Y. Carson: It is a very great pleasure to have this opportunity to meet you face to face, and to really feel your appreciation of America's work in assisting the Allies in another part of the world than that in which the American Government is at present at war.

I had hoped I would have had an opportunity of preparing something that would be of special interest to engineers and others interested, more particularly in engineering work, but, I regret that trying to obtain materials to take on with us more than fully occupied my time.

In coming out from America, it was a new experience for me to pass directly from the depth of winter into a tropical climate, and then to come into your delightful "Fall" weather, as we call it—autumn; and it is most pleasant here, I can assure you, compared with the very bitter winter we had in New York this year. Our coal was short, this year, and many people throughout the country suffered a great deal from the lack of fuel during the bitter winter.

The things that may be of interest to you will, perhaps, be the sort of news which you very likely do not get out here from America; and just what we are doing toward winning the war against the Hun may help you to appreciate America's position in the war. In helping Britain wage war in Asia, America must proceed in a different way to that in which we are fighting the Hun. We are going there to build, or reconstruct, the country—Palestine—which has been devastated and ruined almost completely during the years when the unspeakable Turk has held sway.

In America, when we undertook to recruit an army for this war, we undertook, I believe, to recruit 100 million people; and we found there just as much dissension as you find here, perhaps, among your people. We found that pro-German propaganda had been at work; we can always trace it back to that every time, in the mixing up of one party against another; and I can assure you we had our problems in that direction. President Wilson led us through it. Our President "started in" to tell everyone what his duty was to the country, and he made it plain. He organized what is known there as the Committee on Public Information, to tell people just what we are in the war for; what America went into the war for. It was realized that we are a long way from the fighting, and that it was a difficult thing to make it clear to the people of America just why we are at war; but President Wilson told them "This is not a new war; this is not a new idea which we are fighting for, but the struggle for freedom of conscience as well as for freedom of person, which has been going on ever since history began, and we are fighting that old, old fight to-day." That is a story now brought home to everyone in America. He also told them that everyone, of course, could not go to the Front, but everyone must do his bit in order to help the ones at the Front. Recruiting, therefore, took on a different aspect, a little different character, to that which one might expect recruiting to assume. The business men "got together," organized so that the dollars of the country did as much fighting as they could be expected to do. The Chamber of Commerce of America went to the President, went to the Government officials, and reported that it would be wise for such and such of the business men of the country to be placed under the direction of Government as experts, and to organize the whole arterial commercial system of the country. That has taken place in a remarkably short time, and I can frankly say at this moment that the American Army does consist of 100 million people. Every man, woman, and child in America has, practically speaking, fallen into his or her place. That, likewise, is the reason we are now engaged in turning out ships on an unprecedented, unheard of scale. The programme for this year was set at six million tons of ships; they say no one has ever heard of such a quantity of shipping before in a single year. Well, I feel sure America can do it; the foundations are laid for it, and I feel that not only this amount of shipping, but perhaps more will be constructed; for the best business men, the best statesmen, the best workmen, are behind America, and they will put it through. To-day it is shipping which will win the war. In America we know that very clearly. We realize that men and materials are of no avail unless we can get them to the Front, and that is the big problem, which is being solved as rapidly and as quickly as possible.

In America they have set aside an unprecedented amount of money for carrying forward our war against the Hun. No one has ever heard before of a sum of money of 19 billion dollars—which is 100 thousand million pounds, as you express it—being spent in a single year for the equipment and materials of warfare. That is more money than has been spent by the Government of America during its entire 125 years of existence, including our Civil War. And, knowing these facts, and knowing that we have the right organization to put them through, we can all feel confident that we know the outcome of the war; we all feel confident that Germany must crack under the strain which is brought to bear now on the outer circle of her power.

The engineering side of the war in America, is especially interesting to those of us who are engaged in the practical side of warfare.

We had, as a start, to house our Army; we had no barracks to house the million men, which are drawn from the 10 million men drafted in America, and we had to get these buildings up in three months' time, so as to get a proper start. That meant the laying out of 10 large towns—10 cities—having a population in each of 40,000 or more souls; made up completely with sanitary arrangements, water supply, sewerage, heating systems, streets, theatres, etc. The American contractors and engineers "got together," and they said, "We will do it," and they did it: they built these 10 cities, in many instances, much below the time that had been set for them. That is a remarkable feat, I think, and compares perhaps with the building of the Panama Canal, as an engineering undertaking. It shows what can be done with the power, money, and the men of America; and there also is a bigger and more hopeful side, for when we hear the boast that Germany has made that "German efficiency is the only thing worth while in the world," we now know the efficiency of democracy is much better and more powerful, because it goes right down into the souls of everyone in that democracy. That is the thing which matters to-day: the free efficiency of a freedom loving people, and it will prove better than the tyrannical efficiency which is allowed by a tyrannical governor. The Allies are to-day fighting to make the world a good place to live in.

Now, certainly, when we Americans come here and see what is being done in South Africa, and the way the men here are responding, and the way business men are "getting together" and working out the problems for the war here—perhaps not on as large a scale as America—we realize there is coming about a cementing of the freedom loving peoples of the world: we can also feel in America that we are fighting the same struggle you are fighting, and you can know your are fighting in the same struggle in which we are fighting. If you have a vacancy or a shortage of men at the Front and will call upon America to-day, America will send men to fill their places, to make it complete. That is the spirit in which all the nations on the Allied side are fighting to-day.

There is one other thought that I want to leave with you: How the war was brought home to America. We are a long way from the fighting front; where we are we cannot hear the cannon, we cannot hear the roar of battle; and that was a great handicap to us. It took us a long time to enter it, just because of that. When President Wilson with a Committee on Public Information began to really bring the war home to the people of America, we organized in such a way that facts could be given out to the entire population of America through word-of-mouth messengers. We have there what we call a Four-minute Men Organization: men who volunteer to speak in public places, theatres, and picture shows, between acts, or between reels. A definite, clearly stated message, which comes direct from Washington is being given to the American people. Usually the speech itself was clearly written out; and it soon got everyone throughout the whole country speaking along the same lines. The suggestions which were always put forth were that "You have a place"; "You have a part to play in this war," and, "All you men who cannot go to the Front, can at least sit at your desk carrying on your business, and be of just as much assistance in helping to win the war, by creating war necessities, as the man who goes to the Front, because he depends upon you." And that, gentlemen, was the message which was brought home to the people of America.

The American Red Cross are sending a unit into Palestine, at the invitation of the British Forces in Egypt, in order to fill in, as I have said, a very necessary gap. We are ready to send out our men to go wherever the cause may be greatest; and that is what is bringing us to-day—this unit of the American Red Cross up the East Coast of Africa—with the landing men and materials in Palestine. We are going to be at the direct service of the British Forces, and that is the whole spirit of America; to go out and fill in where we can best fill in. Moreover, after this great struggle is finished, I feel quite confident that the efficiency of free thinking peoples will loom hundreds of times larger and greater and mightier than any German efficiency. I thank you.

Prof. J. A. Wilkinson *(Past-President)*: moved a very hearty vote of thanks to Capt. Carson for his interesting and inspiriting address, and referred to the great work which the American Red Cross had done in the past, and was doing now in this war; and in admiring its wonderful organization, hoped that South Africa would soon be in a position to follow suit.

Mr. H. A. White *(Vice-President)*: briefly seconded.

The Chairman in submitting the vote of thanks, which was passed with acclamation, thought that the establishment of a Department of Public Information was a matter the Union Government might take into consideration, so that the country districts might get a clearer conception of what this war does mean.

Captain H. Y. Carson: Your generous vote of thanks so overcame me, that I are hardly any appropriate words to reply, and I want to tell you how deeply it is appreciated, and with what satisfaction I heard you eulogise the American Red Cross. The American Red Cross, we do feel, is a mighty organization and one which will make its mark on the world, as will all Red Cross organizations throughout the world. The message which I can bring back to my colleagues when I get with them again, is this: In South Africa are to be seen people who are just as enthusiastic in this war as the ones we left behind, and the spirit of democracy here is just as much a spirit of democracy as we boast of in our part of the world. That is a great message to America. We have felt that there is somewhat of a gap between British subjects and American subjects in the full appreciation of democracy: and now we know there is no gap, and that is a thing which is coming home to America, a thing which is coming home to the two greatest countries of the world.

MERCURY.

Mr. E. M. Weston *(Member of Council)*: I made a contribution last month to this discussion on mercury, and am seeking further information. The point I made was that one did not necessarily lose gold by reducing the percentage by amalgamation 5%, or something like that. Following my contribution in the March *Journal* is a note by Mr. H. Ward on the same subject. Mr. Ward's point was that it is absolutely vital to get the last dwt. possible from amalgamation, or it is lost in the cyanide plant. He seemed to take up the position, and gives figures, that the percentage of extraction in the cyanide plant is constant; never more than, as he says, 85%. My argument is this (I am not a metallurgist, and I am speaking quite subject to correction) that when cyaniding sands there is, first, fine free gold, which goes into solution at once, and the only practical loss to which it is subjected may be loss in washings. Then there is gold, say, partially hidden in the sulphides and in the quartz, which requires a somewhat longer treatment to extract. Then there is the finer gold which remains in the quartz particles, and which is not economical to extract except at a prohibitive cost for fine grinding. My contention is this: If one adds to the quantity of fine free gold going to the cyanide works the task of the cyanide metallurgist is not perceptibly added to, as with ordinary care and with that great skill which we know our metallurgists on the Rand exercise, the percentage of extraction would tend to rise from 85% to something like 95%; that is, the richer the tailings are in free gold, the higher the extraction will be. Mr. Ward takes up an entirely opposite attitude. My whole argument was based on the fact that I thought all the gold that was worth extracting could be obtained by a cheaper method than amalgamation to-day, and that if fine gold went to the cyanide plant at all, it would be recovered almost infallibly at possibly no extra cost. I hope someone will sum up this discussion, as I should like an authoritative statement on these two points of view.

The Chairman: I think Mr. Weston is not quite right as regards one point—that is, when the size of the grain of gold which goes through the cyanide plant is appreciable the cyanide solution will not dissolve it in the time in which it is undergoing treatment.

Mr. Weston: That was admitted.

Mr. F. A. G. Maxwell *(Associate)*: Owing to the difficulties attendant on amalgamation when coarse screening is used in the stamp mill, the copper plates in the mills of the Van Ryn Estate were replaced by corduroy and the gold recovered in the form of a rich concentrate.

Recovery of gold in this department could not be abolished owing to the classification equipment being unsuitable and to rectify this fault was impracticable.

Particulars of Plant Used.—

Amalgam Barrels:

	No. 1	No. 2
Inside diameter	27 in.	28 in.
Inside depth	32 in	36 in
Speed	28 r.p.m	33 r.p.m

Grinding charge consists of a total of 400 lb. of stem ends and shoe shanks in each barrel.

Bateas:

Number in use—2.
Inside diameter, each—48 in.
Inside depth, each—6 in. at periphery to 8 in. at centre
Speed, each—18 r.p.m.
Diameter crank circle—6 in.

Grinding charge consists of 18 steel balls diameter 5½ in., weight 186 lb., for each batea.

Below is a statement showing the results obtained for the month of February, 1918. Total tons of ore crushed, 31,700

No plate amalgamation in stamp mill.

Total "Elephant" corduroy used, 560 sq. ft. 4 sq. ft. per stamp; or 0·49 sq. ft. per ton of ore per 24 hours.

Fall of tables, 12½ .

Ratio of water to ore, 5 to 1.

Total concentrate produced 4·309 tons, or 0·272 lb. per ton of ore crushed.

Fine gold contents of concentrate 2·1 .

Concentrate.—

Each charge ground in barrel with 1·3 times its weight of water for the length of time shown below, when 150 oz. mercury was added and the grinding continued for one hour. The charge was then passed through the batea (without mercury bath) as evenly as possible during a time of about 1½ hours. The amalgam from the batea was then cleaned and hand squeezed:—

	No. 1 Barrel. East Mill.	No. 2 Barrel. West Mill.
Tons dry concentrate ground	1·957	2·352
Number of charges ...	28	28
Time grinding without mercury—hours ...	4	5
Amalgam recovered. oz.	2,768	4,014
Fine gold contents amalgam—oz. ...	1,024	1,525
Residue assay—oz. ...	8·57	13·68
Grading analysis, per cent. +·01	6·2	7·7
−·01+·006	15·9	14·3
−·006+·003 ...	32·5	30·1
−·003	45·4	47·9
Mercury added for amalgamation—total oz. ...	4,200	4,780
Mercury recovered by squeezing—total oz. ...	2,520	2,219
Mercury recovered by retorting—total oz. ...	1,543	2,343
Mercury lost grinding concentrates—total oz. ...	137	218
Mercury lost per ton concentrates ground—oz....	70	93

In addition to the area of corduroy mentioned above 12 amalgamated copper plates, of a total area=537 sq. ft., are employed in the tube circuit, on which the loss of mercury for the month amounted to 503 oz.=0·016 oz. per ton crushed.

Gold Recovery.—	Per cent. of Ore Value.
From stamp mill concentrate ...	29·1
From tube mill amalgam ...	37·8
Total	66·9

Total Mercury Consumption.—

	Total Oz.	Oz. per ton of ore crushed.
Due to barrelling concentrates	355	0·011
Due to tube plate amalgamation	503	0·016
Total	858	0·027

I am indebted to Mr. S. C. W. Fleischer, Battery Manager, for supplying the above information, and to Mr. E. G. St. John, the General Manager, for permitting publication.

ASSAY SUPPLIES, AND THE UTILISATION OF SOUTH AFRICAN MATERIALS IN ASSAY OFFICES.

(Dealt with by Messrs. Toombs and J. Watson in March Journal, pp. 220-223.)

Mr. H. A. White *(Vice-President)*: The object of this Society in asking the authors for the two papers dealing with materials used for assaying was to encourage in every possible way the substitution of local manufacture for the imported articles, and where this is not possible, to facilitate such importation as is absolutely necessary. For example, borax is not found in South Africa, and it is desired to obtain suggestions as to the best form in which this substance shall be shipped, bearing in mind that tin plate and wood are scarce in England and ship's space must not be wasted. Thin lead foil, used in assaying bullion is obtainable with difficulty, and ought to be manufactured locally—if thin bars of pure lead were supplied the assayer could easily roll down on the bullion rolls all he requires.

It is very pleasant to note in Mr. Toomb's introduction to this discussion the evident sense of the necessity for economy manifested. In the same way as pure science is mainly concerned with economy of thought so technical applications are never perfect till the utmost economy of labour and material is attained. A very good point is made when the principal function of litharge is emphasized against its subsidiary use as a flux. The best defence that can be put up for its use as a flux is probably to point out that the lead is almost entirely recovered where the assay slags are used in the Taverner process, and waste iron takes its place. The litharge remaining in cupels is also capable of re-use to replace lead nitrate in cyanide charges where such cupels are sent to the battery for this purpose.

It is gratifying to find that Mr. Toombs is among the stalwarts who reject the principally sentimental claims of borax for a home in the assay office. Twenty years ago we were warned that we could not make crucibles in this country,* and the local article is now found to be superior to the best imported, and this object lesson is one of vital importance.

We should like analyses of "cupel powder," and any reason why our local magnesite can not be used under its own name. Mr. Toombs' mealie-meal suggestion is in the correct direction, and I hope it will be accepted as a matter of principle.

The use of cuprous chloride for assaying solution can now claim the further advantages of economy and use of local materials, and the method is even more convenient than Whitby's modification†

We hope that the B.S.A. Explosives Co. may see their way to come to our assistance once more in the matter of nitric acid, as they have done with lead nitrate and hydrochloric acid.

Mr. Watson refers to the fact that muffles are not made locally yet, and the assayers must now get together to find out and remove any reason there may be for this.

We hope to have a full description of the locally made cupel machine, and some further reports of experiments on the use of cement and magnesite for cupels.

Fluor spar should not be used with borax in the same fusion; although this is recommended in most text books, the fact cannot be ignored that the preparation of boron fluoride was first performed by heating together two parts of fluor spar and one of boric acid

$(Na_2B_4O_7 + 6CaF_2 = Na_2O + 6CaO + 4BF_3)$

The extent to which this reaction takes place depends largely on temperature and is the measure of the tendency for the charge to "froth up," referred to by Mr. Watson, and the tendency to "boil over," found by Mr. Murdoch.

When full use is made of local advantages it seems that the mine assay office will be independent of importation except in the matter of fine chemicals and apparatus of which no great amount is required.

As far as the gold smelting operations are concerned, I feel that it is probable a well directed research would enable us to dispense almost entirely with manganese dioxide or any such oxidiser, and that even borax might be driven from its last refuge.

The Chairman: There is one little point I would like to add to this discussion. Of course, since my time as an assayer on the mines, the reverberatory furnace has come into use, and the possibilities of higher temperatures both in fusion and cupellation have to be considered. Of course, in the town we are bound down to the old Cornish furnaces, because the material we have to assay varies enormously in its character, and we have to watch the fusion. It is possible that Mr. White's reference to the effete superstition of many years ago might be perfectly correct when applied to these very high temperatures; but I do not think it applies when one works with the Cornish furnace and use, as we have to now, coke very much inferior to that formerly imported; in fact, we are using largely the "breeze" from the gas-works.

Mr. F. W. Watson *(Member of Council)*: I am pleased to notice that the subject of economy in assay practice on the Rand has been referred to in last month's *Journal* by Messrs. C. Toombs and J. Watson. Mr. Toombs's remarks ought to be useful to our mine assayers by giving them a few hints in economy of supplies, and I am pleased to notice that he finds that cupels made with the lower part composed of cement, and the top part of cupel powder, have given satisfaction. We have found no cause for complaint with these cupels, and have not noticed any abnormal cracking of the surface compared with cupels made entirely of mabor or cupellite.

With regard to the use of borax substitute, as Mr. Toombs calls it, or fluorspar, as Mr. Watson more plainly terms it, I do not think that any assayer has claimed that fluorspar is a substitute for borax. In the first place, the melting points are far apart and borax, as we know, melts readily in the charge and works its way through comparatively early in the fusion. One point must be remembered however and that is the manner in which both boron and fluorine react with silica, the main constituent in ordinary Rand samples, to form borosilicates or fluosilicates as the case may be. We have found that a small amount of fluorspar, added to the flux instead of borax, gives us a more fluid slag and a clean lead button without having any adverse effect on the assay value or showing abnormal corrosion of the crucibles. This fluorspar is not added in conjunction with borax; the latter is omitted entirely, so that there is no chance of formation of boron fluoride as mentioned by Mr. White.

---

* *Chem. Metal. & Min. Soc.*, Vol. II, p. [illegible]

† See this *Journal*, Vol. X., p. [illegible]

The chief source of waste, to my mind, in ordinary assay office practice is in the use of nitric acid, an imported article. Let us consider first bullion assaying in which two acids are used, the first containing two of water to one of nitric acid, and the second one of water to one of acid. The nitric acid is usually sold at 1·42 specific gravity which means that one litre of acid contains about 990 gm. of HNO_3, according to the Chemists' Year Book (1915), by F. W. Atack. Now the first acid, we will say, has a volume of 150 cc. made up of 50 cc. nitric acid and 100 cc. of water, that means between 49 and 50 gm. of HNO_3 are contained in this parting acid.

We use approximately 250 mgm. of bullion for an assay, and about 225 mgm. of check gold. Consider how much nitric acid is required to part these cornets, allowing 2·5 parts of silver to one of gold:—about 0·6 gm. of silver is contained in each cornet. Assaying six bars in duplicate with one check would mean 13 cornets, or about 7·8 gm. of silver, this would require just over 4·5 gm. of HNO_3, theoretically, as 107 parts of silver combine with 63 parts of HNO_3. What becomes of this large excess of acid? Is it in most cases brought up to strength and used again? I doubt it.

The second acid (one of acid to one of water) is a much more vital point, as I consider that only a small fraction of the silver, originally present, is left in the cornets after the first acid treatment, consequently very little of this second acid is used up in dissolving silver. If the specific gravity of this acid were taken, and if, after use, the solution were made up to the same gravity it could be used many times.

In parting ordinary reduction works and mine samples we find that the parting acid can be used several times without impairing its potency, as the excess used in the first instance is necessarily very great, consequently the acid first poured off from the parted bead is kept in a separate bottle from the wash water, and is used again.

Mr. Watson has remarked on the use of South African sodium carbonate, and he recommends that the sodium chloride should be determined occasionally. It seems to me that the more sensible thing is to determine the Na_2CO_3 present in the sample, as this is the active principle, and the determination is very simple.

Prof. G. H. Stanley *(Past-President)* I gather from what Mr. White and Mr. Watson have said that nitric acid is not considered to be available locally, of local manufacture, but I believe that nitric acid of sufficient purity is being made at Umbogintwini, by Messrs. Kynoch's.

Prof. J. A. Wilkinson *(Past-President)*. The standard of purity guaranteed is that of the British Pharmacopœia and, as far as I can judge, they seem to be quite up to the standard, which I should think would be required for ordinary assay work.

Mr. C. Toombs *(Member of Council)*. I have just received a letter from Kynoch's, Ltd., stating that they are manufacturing nitric acid in every way equal to the imported article, as well as hydrochloric, sulphuric and other acids, etc.

With regard to the local manufacture of muffles: On this month's requisition I have been supplied with muffles made by the Consolidated Brick and Tile Co. They appear to be very well finished, and made to the outside measurements of the size order. The walls, however, are extremely thick, leaving the inside measurements considerably smaller than the imported muffles, and consequently would not carry the same number of cupels. As this would mean considerable alterations in my routine practice, I was reluctantly obliged to return them without trial, but hope to receive a satisfactory muffle from the same firm in the near future.

With regard to the local soda carbonate, it is essential that its purity be checked from time to time. During the week two different samples I tested went 91·5% and 82·5%, with sodium chloride contents 1·1% and 10·2% respectively, the latter being very unsatisfactory.

Mr. C. A. Meiklejohn *(Member)*: I should like to make a few remarks on some of the points raised by Messrs. Toombs and Watson.

Sodium Carbonate.—The use of the imported article has long since been discontinued for assay use at the Rand Mines laboratory. A series of tests were made which, as anticipated, demonstrated that the local carbonate could be used without in any way adversely affecting the value of the assay. The results of these tests are as follows.—

	Local Carbonate. dwt. pt.	Imported Carbonate. dwt. pt.
1. Slime charge	1·36	1·35
2. Slime residue	0·13	0·11
3. Sand charge	7·06	7·09
4. Sand charge (oxidised)	7·03	6.99

No. 3 was a sand charge from one of the properties on the Rand, and No. 4 an oxidised ore containing a fair amount of ferric oxide. The local carbonate we find to contain from 90 to 95 Na_2CO_3 with varying amounts of moisture present. The chloride we have found in samples tested to be fairly constant, about 1·8 NaCl.

Cupels.—I am surprised to hear of Mr. Watson's experience in the use of cupels with a cement base. We have used for some time and are still using composite cupels prepared by ourselves. The cupels consist of from three-quarters to seven-eights cement base faced with cupel powder. We have always found their use to be quite satisfactory. The price of the local cupel powder appears to depend on that of the imported, and I agree with Mr. Toombs that the price could be reduced and still leave a fair profit for the manufacturers.

Borax and Borax Substitute. — Mr. Toombs has referred to borax as an "effete superstition." Doubtless an extravagant amount of borax has been used in the past when the same was much cheaper and more easily obtainable than it is at the present time. We all realise the extreme necessity for economy in ship space and material, but at the same time the main objective is accuracy, and if Mr. Toombs means, as I take it, that the use of borax in assaying could be entirely dispensed with, and its functions fulfilled by sodium carbonate, I cannot agree with him.

Some considerable time ago we cut down the amount of borax in our fluxes very considerably, replacing it in part with fluorspar. This we have found to be quite satisfactory, and we have not been troubled, as was Mr. Watson's experience, with pots boiling over. Further, the substitution of a part of the borax by a much smaller quantity of fluorspar (about one-third) has lengthened the life of our crucibles.

Crucibles and Muffles.—The locally made crucibles, as at present supplied, are to my mind, fully as good as the imported article, and it should not be beyond the power of the local manufacturers to supply us with muffles of a satisfactory quality.

Lead Foil for Bullion Assays.—Hitherto we have used the imported foil for bullion assays, but recently we tried what could be done in rolling our own lead foil. A sample of lead, carrying some 3 dwt. silver per ton with a mere trace of gold was obtained locally. This we cast and rolled. The result was quite satisfactory, and I can see no reason why assayers should not prepare the lead foil for their own use.

FURTHER NOTES ON SANDFILLING OF MINES.

By C. H. Greathead (Member).

The essential features of the sandfilling plant on the Simmer and Jack Proprietary Mines, Limited, have been fully described by Dr. W. A. Caldecott and Mr. O. P. Powell in a paper read before this Society in September, 1913, and since, there have been no radical changes in the principles of sandfilling as then practised.

I therefore intend bringing to the notice of this Society minor alterations that have been introduced in practice, and the development of various methods that have been put into practice in the reclaiming of pillars, foot and hanging walls in portions of the mine that have been virtually abandoned for a considerable number of years, and also on the effect that sandfilling has had on portions of the mine where large areas have been sandfilled owing to there having been a considerable movement in the hanging.

A further improvement in draining areas which have only one or two boxholes at the bottom to drain through (the two sides being contained between dikes, or solid blocks of ground), or areas which for some reason or other contain an excessive amount of water in the sand and which must be drained rapidly, has been effected by using a launder with a false bottom with ash clinker on top of it. This launder replaces the old square box launder with holes in the sides which had to be plugged as the sand and water rose and covered the holes. Occasionally the native watching the work forgot to put the plug in, and a considerable amount of sand was washed into the drives. The clinker launder obviates this danger and besides requiring no supervision, also continues to drain below the surface of the sand for a considerable time. Launders have been standardised, and we only use three patterns now (Fig. I.).

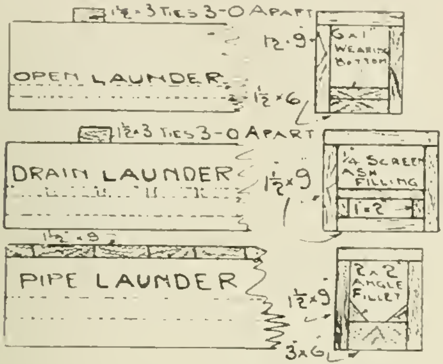


Fig. I.

In the case of drives on reef which have crushed badly in parts, and where it is impossible to put the barrier at the back of the drive pillars owing to the stope above having caved in, ordinary square setting is put in and lagged over with 3 in. × 9 in. deals or 1½ in. × 9 in. hardwood planks; on the top of the planks a 6 in. layer of ash clinker, coarse at the bottom and finer on top, is placed, and the stope filled as usual. The ends of the square setting are masoned up sufficiently well to be sand proof, which is rather expensive, but has answered remarkably well in places which otherwise would have been impossible to sandfill. One level which was sandfilled in this manner nearly three years ago is at present in perfect order and has taken no further weight. It is not, however, always necessary to put in complete sets as often, only a cap piece or a leg and cap piece are necessary.

In stope barriers jute matting has been tried instead of cocoanut matting, but it has been discarded again as it rots too rapidly, and when wet swells and tends to hold water instead of filtering rapidly. "V" shaped launders have also been tried, but have not been found very satisfactory as they are liable to overflow if the sand pulp is thick. In some wide stopes where mining operations are still being carried on, we have partly filled the stope without any side barrier, by shovelling up the sand in the form of a wall, much on the same principle as a slime dam wall, and have thus filled a stope having a 200 ft. back—the sand wall is battered at an angle of about 35 degrees and the water is carried off by means of a launder and pipes, which are altered to suit daily requirements (see Fig. II.). An ash drain launder might be more effective, but by carrying the drain pipes outside the sandfilled area they are easily recovered whereas the ash drain launder would either have to be abandoned or dug out.

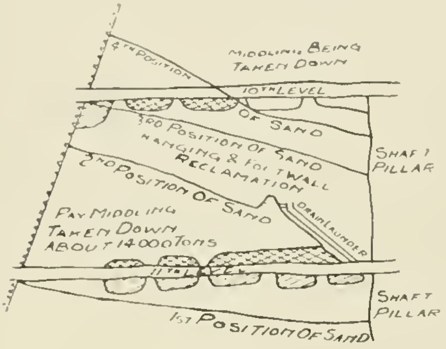


Fig. II.

Towards the middle of 1915 a considerable movement of the hanging wall commenced on the eastern boundary on the 14th level, and this movement steadily spread in a south and south-westerly direction down to the 28th level and seriously threatened the loss of about one-third of the No. 3 shaft section of the mine. Several reclamation sections had to be abandoned owing to the impossibility of making these places safe, owing both to the expense and height of the workings, which in places were 15 ft. in width. Several stope faces were also abandoned as the hanging broke the timber props and caved in over the pigstyes and packs; these "falls" commenced in the older portions of the stopes where the supports were insufficient, but also extended to the face where the pigstyes were put in systematically and which were very well timbered, but this did not stop the movement which by that time had become very serious. Several accidents, two of which were fatal, occurred due to pressure bursts—while the 16th to 27th levels caved in completely in the area of the movement, necessitating reopening and retimbering.

Sandfilling was commenced, and a scheme laid out in order to save those stopes that were still being worked on the 27th and 28th levels. Barriers of light timber and matting were run up from the drive pillars parallel to the stope faces and about 15 ft. distant, the boxholes were closed off with lagging, matting and cinders and the space between sandfilled. This in no way interfered with the current mining operations, and it was noticed that, when the stope had become about half full of sand, pressure bursts on the face became less frequent and by the time the sand had filled the stope these had almost ceased. Along the drives, especially on 26th level, where several accidents had occurred owing to the drive pillars bursting, the movement ceased entirely after the stopes above and below had been filled for several months, and up to the present moment, a period over two years, there have been no signs of any further movement. Sand has now been filled up to the 25th level, and a considerable reclamation foot and hanging and drive pillars has been obtained along the 25th and 26th levels as well as a considerable amount of sweepings in the old stopes, portions of which we have been able to re-enter. The tonnage obtained from this work amounted to 86,976 tons of payable ore. Two faces which were last worked in July, 1913, and July, 1914, have been recovered and are now being worked. Sandfilling has been discontinued in this area for some months to enable the recovery of sweepings and reclamation rock, and when this has been done, sandfilling will be restarted for the further recovery of reclamation rock higher up in the mine.

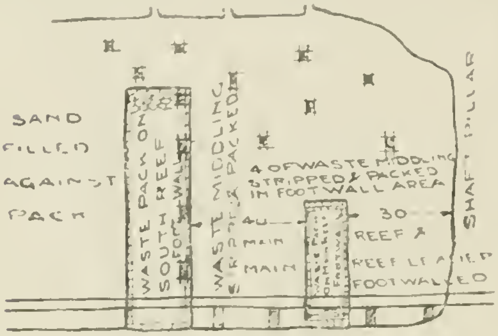


Fig. III.

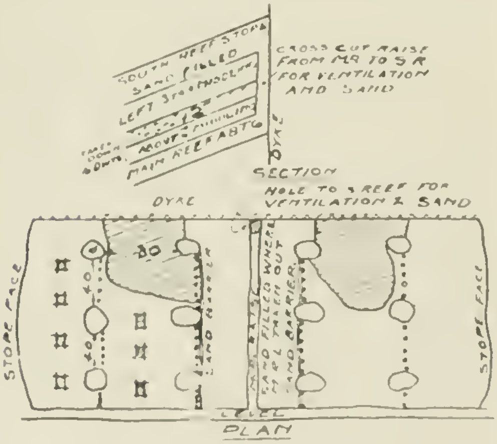

SOUTH REEF STOPE SAND FILLED
LEFT STANDING
MAIN REEF ABOVE
CROSS CUT RAISE FROM MR TO SR FOR VENTILATION AND SAND
DYKE
SECTION
HOLE TO S REEF FOR VENTILATION & SAND
DYKE
30
STOPE FACE
STOPE FACE
SAND FILLED
SAND BARRIER
LEVEL
PLAN

Fig. IV

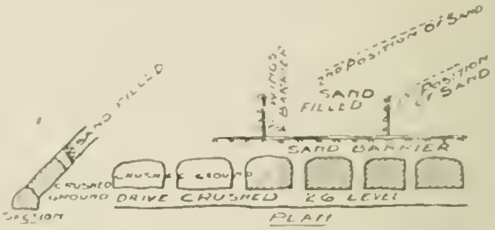


Fig. V.

At the Nos. 1 and 2 shaft sections a similar condition prevailed and several valuable faces were recovered after entirely filling the stopes and then flushing out a raise through the sand along the faces. It is essential when raising through sandfilling areas to keep next the hanging wall of the stope.

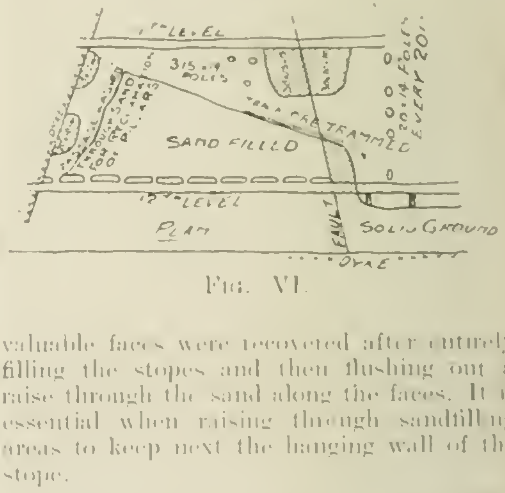


Fig. VI.

Figs. III., IV., V. and VI. illustrate various methods of reclamation work in conjunction with sandfilling.

The area of claims filled with sand at the 31st of December, 1917, is equivalent to 77·7 claims, and represents 23·58% of the area stoped out. The exact number of tons of sand lowered is not obtainable as no early records were kept, but the known tonnage that has been lowered up to the 31st December, 1917, is 1,722,585 tons. The following tabulation of sandfilling costs may be of interest.

A Statement of Tonnages and Costs of handling Sand, the disposal of Sand to Dump and Sand-filling operations Underground. The period being since the commencement of Sand-filling operations in May, 1910, to December, 1917

Distribution of Costs for the Period January to December 1917.	Surface Costs.		Underground Costs.		Total Costs.	
	Total.	Per Ton of Sand lowered in pence.	Total.	Per Ton of Sand lowered in pence.	Total.	Per Ton of Sand lowered in pence.
White Labour.	£1,378 2 3	·897	£2,699 17 10	1·758	£4,078 0 1	2·655
Native Labour.	255 2 9	·166	1,046 17 2	·682	1,301 19 11	·847
Stores... ...	379 2 11	·247	4,084 10 3	2·660	4,463 13 2	2·907
Workshops	210 18 7	·137	181 13 8	·118	392 12 3	·256
Power... ...	474 4 9	·309	—	—	474 4 9	·309
Totals ...	2,697 11 3	1·756	8,012 18 11	5·218	10,710 10 2	6·974

Current Sand sent to Surface Dump and Underground.—Period May, 1910, to June, 1915.

Tons.	Total Costs.	Cost per ton of Sand to Surface Dump in pence	Cost per Ton of Sand to Sand Filling in pence.	Cost per Ton of Sand to Surface Dump and to Sand Filling in pence.	Cost of Sand Filling per Ton of Ore Milled in pence.
1,692,630 700,549	£45,114 10 8	4·524		6·497	3·624
700,549	19,674 6 11		6·740		
2,393,179	64,788 17 11	4·524	6·740	6·497	3·624

Total Tonnage of Sand sent Underground since commencement of Sand Filling Period May, 1910, to December, 1917.

Total Tons of Sand,	Total Cost of Sand lowered.	Cost per Ton of Sand lowered in pence.	Cost of Sand Filling per Ton of Ore Milled in pence.
1,722,585	£13,595 15 2	6·074	1·685

Total Current Sand sent Underground. Period July, 1915, to December, 1917.

Total Tons of Sand sent Underground.	Total Costs.	Cost per Ton of Sand Lowered in pence.	Cost of Sand Filling per Ton of Ore Milled in pence.
1,022,036	£22,559 4 7	5 297	2·822

Total Current Sand sent to Dump and Underground. Period May, 1910, to December, 1917.

Total Tons.	Total Costs	Cost per Ton of Sand to Surface and Underground in pence	Cost of Sand Filling per Ton of Ore Milled in pence
2,393,179	£64,788 17 7	6·497	3 624
1,022,036	22,559 4 7	5·297	2·822
3,415,215	87,318 2 2	6 138	3 376

Sand sent to Dump during the period 1908 and 1909.

Total Tons of Sand sent to Dump.	Total Costs.	Cost per Ton of Sand sent to Dump in pence.
1,028,053	£21,010 1 7	5 904

From the schedule of costs it will be observed that the total cost of disposal of sand on surface and sandfilling underground for the year ending 1917, amounted to 6·971 pence per ton of sand filled, and the cost of disposal of sand to dump for the years 1908-1909 (before sandfilling was started) amounted to 5·901 per ton of sand to dump—making a difference of 1·070 pence in favour of disposal of sand to dump. This is more than counterbalanced by the additional advantages of having the old worked-out areas permanently supported, the saving in cost of labour and material in retimbering and supporting these areas, to say nothing of the additional safety, better ventilation, and additional ore obtained.

Mr. E. C. J. Meyer *(Member)*: As one who has had to do a great deal of sand filling, I have taken an interest in this paper by Mr. Greathead. At the Simmer and Jack 1½ million tons have been lowered into the workings. At the mine I am connected with two million tons have been lowered, and I think we have had much the same experience. Amongst other things, our accident rate has considerably decreased. I am very glad to see my accident rate for the past year has been the lowest on record, and I put it down mainly to sand filling. I have very much pleasure in proposing a vote of thanks for the very interesting paper read this evening by Mr. Greathead.

Mr. E. M. Weston *(Member of Council)*: I have very much pleasure in seconding the vote of thanks. Really, this paper is something valuable as a commentary on the other papers we have had on the support of underground workings, and, I think, it read in connection with those, we get some quite valuable sidelights on the subject. Personally, I do not think that sand filling has, among certain mines and certain groups, received the attention that perhaps it might have had. There does seem, in certain quarters, rather a disregard of the many advantageous results which may be obtained from its use in certain circumstances. Of course, the whole point of securing ground is to know just what is the best method to use under any given circumstances, what will be the cheapest in the long run; and here, no doubt, we have a method which has been applied with brains and with the very greatest success.

ELECTRIC FURNACE MANUFACTURE OF SHOES AND DIES ON THE WITWATERSRAND.

By Geo. H. Stanley, A.R.S.M., F.I.C., M.I.M.M. (Past-President)

and

ELECTRIC STEEL-MELTING PLANT.

By Prof. W. Buchanan, B.Sc., A.R.C.S., M.I.E.E. (Past-President, S.A. Institute of Electrical Engineers)

(Printed in Journal, September, 1917.)

DISCUSSION.

Mr. J. M. Dixon *(Member)*: The following figures and remarks on the behaviour of local shoes and dies used on the Robinson Deep may be of interest. Of the total number of shoes supplied 53·1 broke at the shank, many of them being honeycombed with blow-holes, although others did not reveal any weakness in this respect at the fracture. A very large percentage of shoes had holes of varying sizes and depths in the face and extending up the body, and some remarkable difference in life of shoes running in the same battery were probably caused by this; differences of from 10 lb. to 40 lb. in weight of shoes of similar dimensions were observed. Five shoes broke while being picked up by the stamp, giving no life at all, and 20 of those which broke did so in the first twenty-four hours of use. It may be remarked here that these results confirm some experiments made some twelve years back at the Simmer and Jack with imported cast steel shoes, the conclusion then come to was that a cast shoe would not stand up to the work. A consignment of cast shoes (imported) are now being used on this mine, and so far of 55 installed 6 or 10·9 have broken at the shank, and as they have not been running long it seems reasonable to expect further breakages. Of imported forged shoes used on this plant during the past twelve months 3·5 have broken. The local dies supplied have been quite a success, a number have broken to pieces when nearing completion, but in spite of this the average life is slightly better than that of the imported.

Comparison of life and breakages of local and imported shoes and dies of equal weights

Shoes.	Local	Imported	% of Life compared with Imported.
No. Used ...	190	600	—
Average life (days)	23	46	50·0
No. broken	101	21	—
Percentage broken ...	53·1	3·5	—
Life of broken (days)...	11	8	—
Life of unbroken (days)	37	46	80·1
Dies—			
No. used	150	600	—
Average life (days) ..	67	64	104·6

The grouping of the results in periods will show that no progress has been made in improving the shoes, in fact the earliest consignment were better than the last received.

Period	No. Used	Av. Life Days.	Broken. No.	Broken.
Jan.—March, 1917 ..	45	30	15	33
April—July, 1917 ...	30	23	14	46
Aug.—Nov., 1917 ...	70	22	42	60
Dec., 1917—Mar., 1918	45	18	30	66

The committee appointed to investigate the manufacture of these articles stated in their report that "By forging a very satisfactory product should be made," and it seems a pity that the necessary reheating furnace and steam hammer was not included in the plant laid down.

During 1913, with a view to placing a contract for forged shoes and dies, trial lots were obtained from four leading makers, and the results given below may be of interest. The average weight of stamps was approximately 1,550 lb. and the duty 15 to 16 tons. The shoes were 15 in. × 9 in. and the weight 287 lb. :—

Maker.	No. Used.	Av. Life Days.	No. Broken.	%
A. ...	65	68	18	20·0
B.	75	64	16	21·3
C.	80	66	4	5·0
D.	75	67	14	18·7

I am indebted to Mr. Wessels, Manager, Robinson Deep, Limited, for permission to use the above figures.

Mr. E. M. Weston (*Member of Council*): Some little time ago I made a suggestion that the life of these shanks might be improved by reinforcing them with steel or wrought iron rods—that is, by casting around them. Since I made that suggestion, the Engineer of one of the large mines on the Rand has told me that at one period he had to use cast-iron shoes which were cast locally, and this trouble of breakages developed to a very serious extent. He said he got over it by doing what I suggested—that is, he put a piece of inch jumper steel—or ⅞ in., I forget which—and cast the shoe around it. I have also heard (I am not making any accusations against anybody), that mill men are not always as careful as they might be to use standard wedges, so that the shanks can go right home and get the support they are entitled to. I am not saying that they do or do not; but I have heard that stated against them—that shanks generally, in mills, sometimes have treatment that is scarcely fair.

Mr. A. B. Inglis (*Member*): The following notes on the locally manufactured electric smelted shoes and dies may be of interest. The period under review covers from January, 1917, to February, 1918.

	Shoes.	Dies.
Total number used ...	305	205
Average weight ...	237·5 lb	132·75 lb
Average running time	56 days	81 days

As a basis of comparison—taking the average running time and weight of the imported shoe as 81 days and 272 lb., and the die as 112 days and 151 lb., gives the efficiency of the local shoe as 76·35 and the die 82·2 %.

The number of shoes broken, excluding any under 4 in., was 133 43·6 of the total used.

The number of shanks broken within seven days of being put in was 32 24 % of the total broken, or 10·5 % of the total used.

Average height of broken shoes, 9·6 in.

The maximum running time of shoe 76·1 days.

The maximum running time of die—97·1 days.

The minimum running time of shoe—37·1 days.

The minimum running time of die—67·9 days.

During the months November and December, the percentage of broken shanks rose to 55·5 in 60 broken and 108 put in: this, however, may be due to the fact that we were running almost wholly with the local shoe, and a contributary factor at that period was the heavy rainfall into our exposed ore bins, causing a very irregular feed to the boxes and consequent pounding of the stamps. The wear of the shoe was, as a rule, more rapid on the lower six inches, due probably to an irregular core or blow hole in the centre of the bottom causing this wearing face to become cup-shaped.

Attempts at re-shanking proved unsuccessful owing to the metal crumbling when brought to red heat.

The dies wore uniformly, and generally maintained a good working face. In a few cases where the base showed many blow holes, the dies broke when worn down to about 2½ in.

Mr. D. J. Pepler (*Member*): At the Ferreira Deep mine we have installed, up to date, 195 local made electric furnace shoes and 195 dies, results of which and comparison with the imported article, are as follows:

Average steel worn per day per set of five local made shoes	13·566 lb.
Average steel worn per day per set of five imported shoes ...	11·761 lb.

The average life of local made shoes is therefore 84·683 compared with that of the imported shoes.

Average steel worn per day per set of five local made dies	6·033 lb.
Average steel worn per day per set of five imported dies	4·760 lb.

The average life of local made dies is therefore 73·257 compared with the imported dies.

Breakages.—In the first consignment of local electric furnace made shoes, the percentage of breakages was rather high in shanks, later consignments were very much improved. Taking the average on total supplied up to date, the breakages were quite normal as compared with the imported article.

The first consignments I found to be badly air-holed, also, many shoes were cored at the face causing abnormal wear. Both shoes and dies were badly made; dies were full of lumps at face and base, and in many cases had to be returned to the makers as they were unfit to place in the mortar. In many cases the shoes were not round; this was caused by the moulds having shifted, and gave much trouble in sticking same to heads. The supplies of late have been much improved on, but there is still room for improvement.

I have to return some dies, which were supplied last month, on account of lumps on the face and base, and which cannot be placed in the mortar in their present condition. I am sure that by the makers exercising a little care in the moulding, the aforesaid objections can be overcome, and the local article brought in line with that of the imported.

THE MANUFACTURE OF CRUDE SODIUM MANGANATE FOR USE ON THE MINES.

By F. Wartenweiler (Member of Council)

(Printed in Journal, January, 1918.)

DISCUSSION.

Mr. John Watson (*Member of Council*): The old saying that "history repeats itself" seems to be just as true in the domain of applied chemistry as in that of politics or sociology.

About 1886, the Metropolitan Board of Works had to tackle the serious problem of rendering innocuous a huge floating island of semi-solid sewage, which floated back and forward in the river Thames, as each tide rose and fell, which, during the summer months, caused a great nuisance and threatened a serious epidemic of zymotic disease. A salt, new to the heavy chemical trade came to the rescue, viz., manganate of soda. Here, some thirty years later, the gold mines of the Rand required a cheaper cyanicide and oxidiser to take the place of potassium permanganate and, again, manganate of soda saves the situation.

Amongst the chemists who were engaged on the question of London sewage, I may mention Dr. C. Meymott Tidy,* Sir Frederick Abel, Dr. Odling and Sir Henry Roscoe. The latter was called in to report to the Metropolitan Board of Works.†

Deodorisation, under the Roscoe *regime*, was commenced at both sewage outfalls, Crossness and Barking, in May, 1888; first bleaching powder was used then sodium manganate. Barking is on the north side of the Thames, Crossness on the south, and these places are about 10 miles (as the crow flies) east of Charing Cross.

In 1887 chemicals to the value of £12,467 had been used, and for 1888 the value used was £21,357, manganate having been obtained at a lower contract price. The writer got a circular on manganate of soda at the Glasgow Exhibition of 1888, issued by the Widnes Alkali Co., Ltd., which states that the Metropolitan Board were employing upwards of 6,000 tons per annum of manganate for the London sewage.

Caustic Soda.—Mr. Wartenweiler used commercial caustic 98·98 (99) purity. There appears to be a misprint here. At any rate, this suggests the Greenbank brand from St. Helens, Lancs. This firm broke away from the trade custom of selling caustic soda according to its percentage of available alkali. We must give them credit, however, of being about the only works which put a granulated or pulverised caustic on the market.

---

* See J. Soc. Chem. Ind., 1886, pp. 344-9.

† See J. Soc. Chem. Ind. 1889, pp. 409-410.

The following comparative analyses, made by the writer, will illustrate the above point:—

	Greenbank Ground Caustic Soda	Allhusen's Ne.-on-Tyne 77% Caustic.
Sodium hydrate ..	93·33	97·24
Sodium carbonate ...	2·72	1·14
Sodium chloride ...	1·40	0·57
Sodium sulphate .	1·78	0·74
Sodium silicate ..	0·46	0·30
Sodium aluminate ...	0·08	0·03
Insoluble in water ..	0·13	Nil
Moisture	0·09	0·10
	99·99	100·12
Available soda (Na_2O) by English alkalimetric test	75·17	77·18

The Greenbank method of calculation was to take the whole of the available alkali and calculate it all into NaOH. It was not the custom of the trade, and my old manager used to refer to it as a "hanky-panky" trick.

Manganese.—This point has already been touched on by Mr. F. W. Watson. There is, I understand, at least one fairly large deposit of manganese in the Transvaal, averaging in the dry state about 64% to 65% MnO_2. On the Tyne, for chlorine production, we used to get manganese, varying from 72% up to 83% MnO_2, stated on the dry ore. This manganese came chiefly from Spain, the Caucasus and Japan.

Manganate of Soda was made on the Tyne, notably by the Jarrow Chemical Co., in hand furnaces. The Widnes Alkali Co., Ltd., in Lancashire, used a mechanical furnace with revolving stirrers for mixing the molten caustic soda (baled fresh from a finishing pot), with the manganese.

THE ESTIMATION OF INJURIOUS DUST IN MINE AIR BY THE KOTZÉ KONIMETER.

By John Innes (Associate).

Printed in Journal, March, 1918.)

Mr. J. Innes *(Associate)*: I would like to correct the following misprints in the paper as published:—

Page 204—No. 8 should read No. 9
Page 204—No. 9 should read No. 10
Page 205—No. 10 should read No. 8

DISCUSSION.

Mr. Jas. Gray *(Member of Council)* In congratulating Mr. Innes on his thorough description of the application of the Kotzé konimeter for the determination of injurious dust in mine air, I desire to express my opinion that the Society has been honoured by receiving this contribution, which may be described as the first official description of this ingenious instrument.

An excellent summary of the methods used, prior to the introduction of the konimeter, for the estimation of dust in mine air is to be found in the General Report of the Miners' Phthisis Prevention Committee, issued in March, 1916. A study of this report will well repay all interested in the phthisis problem. This summary points out that the use of sugar as a filtering medium for dust in mine air was first suggested in this country in 1907, by Mr. W. H. Jollyman, F.I.C., in connection with the Mining Regulations' Commission, a fact with which I am well acquainted, as the work of collecting the few samples then examined fell to my lot.

It must be admitted that excellent as was the pioneering work done with the aid of the sugar tube method its failure, as stated by Mr. Innes, to differentiate between injurious and non-injurious dust was a serious handicap in the examination of mine air. It is also true, that a large proportion of the injurious dust is not retained on sugar, and the adoption of the grading method to such samples would supply an incorrect result though the difference to the gravimetric result would be negligible.

The principle in use in the konimeter is sound and, although opinions may differ regarding the type of instrument, the shape of the slide and other sundry details, yet as was the case with the sugar tube method practice will result in building up an instrument, if this is not already the case with the konimeter, which will satisfy the most meticulous.

I regret I am unable to bring forward any data bearing on the use of the konimeter, but I hope that those who are in the possession of such data will not hesitate to take advantage of this discussion to bring forward any information either for or against this instrument. There are those of us who hold that the Kotzé konimeter constitutes a decided advance in the investigation of the problem of miners' phthisis, and judging from the following extract from the *Star* of the 25th March, 1918, from the Presidential Address of Mr. E. A. Wallers, C.B.E., to the Chamber of Mines, there are others in authoritative quarters who have a different opinion. The extract is as follows:

". . . . . You will understand that it is impossible in many cases to count the particles of dust with any close degree of accuracy, but they are often sufficiently capable of computation to enable an approximate idea of the dust conditions of the air in the place sampled to be arrived at. The konimeter, therefore, forms a most useful and convenient complement to the more complete sugar tube method of sampling."

In conclusion, I desire to again thank Mr. Innes for his able and comprehensive exposition of the construction and uses of the Kotzé konimeter.

Mr. J. Whitehouse (*Associate*): I should like to express my appreciation of the excellent work that the author has done, with regard to the estimation of the number of particles of dust in mine air. On reading through the paper, it is quite evident that a great deal was achieved even in the short time that Mr. Innes was at work, and the information he has given us is most valuable, and marks a considerable step forward in our knowledge of this important subject.

I think, however, that at the last meeting when the paper was read, a rather wrong impression was given, quite accidentally, to a number of those who were present that evening; and from their remarks afterwards, it would appear that they gathered the impression that axial water-fed machines were a death trap to any man employed on working them, and that the machines of the old type without any water-feed whatsoever were actually less dangerous. I fail to see any justification for that impression having been given, since there is nothing in the paper which can possibly be interpreted in that way, and, I think, in fairness to those men who are employed on these machines to-day, this point should be made clear, since I have noticed in the remarks made by one of two miners actually working axial water-fed machines, that a great fear was at once aroused in their minds that they had embarked upon work which was particularly dangerous.

It is rather difficult for one in so short a time after the reading of the paper to give definite figures, and, in any case, a mine manager has little time for research, but I think attention should be drawn to one or two points raised at the last meeting.

It will be noticed in the paper that the proportion of fine particles—that is, particles below 5 microns—which are found in dust from axial water-fed machines and from other design, are more or less the same, and if we take some of the sections which are reprinted in the *Journal*, No. 26, for instance, which is given as an instance of a very bad sample, and is a result obtained with axial water-fed machines, and compare it with No. 31, which is a sample taken with ordinary reciprocating machines, it will be found that the percentage of fine dust under the two conditions is approximately the same, 99 in the one case and 95 in the other. The actual proportion of fine dust in the samples therefore only differs by about 1. Now, it might be argued that this is quite true, but that the actual number of these particles is very much greater in the one case than in the other. The weights by the sugar tube method, however, do not suggest this, since they are 3·6 and 3·0 respectively. Results obtained by the Miners' Phthisis Prevention Committee show in one instance with reciprocating machines 387 particles per cc., and with axial water-fed machines 343, or approximately the same. There are instances, however, in which the water-fed machines have given up to 1,500, and I would suggest, therefore, that there is some reason which has not yet been found for these variations. Again, ore bins give up to 695 particles per cc., so that the axial water-fed machine by no means has a monopoly in the creation of dangerous dust.

Now, going back a short time—it is only a short time, after all—to the time when the first samples were taken, I understand that the very first sample showed that per cubic metre the actual weight of dust was something like 1,500 mgm., and it was by no means exceptional to find samples giving, at any rate, 100 mgm. The weights of some of the samples given in connection with this paper show something like 3 mgm. per cubic metre, so that assuming that to-day axial water-fed machines show 1 more fine dust than reciprocating machines, the conditions attending their use are still many times better and safer than conditions were ten years ago.

Recently, the health of three men was investigated, whose period of service underground has been considerable, and who have been employed on axial water-fed machines from the time they came to this country, which is about six years. These three men are successful and industrious workers, and it was found that any one of the three would pass as a first class life to-day.

Now, if the impression gathered a month ago in this room were a true one, I do not think we should have an instance of three men who to-day have apparently suffered absolutely no harm after six years' employment on axial water-fed machines.

To-day we are comparing very small differences, but whatever the difference is between the two types of machines, the improvement which has taken place during the last ten years is so enormous that there is no justification for fear for the future.

The results obtained by the konimeter vary considerably, and two men operating alongside each other will often show enormously different results. In some cases, where the sugar tube method shows a considerable weight of dust, no spot at all may be obtained with the konimeter. Probably the explanation is that the sample which is taken by the sugar tube method is 66,000 times in volume greater than that which is operated upon by the konimeter, and hence it is conceivable that enormous variations can occur. Again, with the same type of machine working under apparently the same conditions, enormously different results can be obtained in the number of particles per cc., varying from 200 up to 2,000. Therefore, I would suggest that the local manufacture of the konimeter, which must necessarily be difficult, and also the unknown factors which enter into the operation of the machines all tend to create these differences, and I think we have justification for expressing the view that the operation of the axial water-fed machines and possibly the konimeter is not absolutely understood to-day, that there are factors which are not known to us, and I would suggest that before condemning any type of machine we should wait until the results of the tests which are now being made, have been published.

Mr. E. C. J. Meyer *(Member)*: I listened with great interest to the paper read by Mr. Innes before this Society a month ago, on the estimation of injurious dust in mine air by the Kotzé konimeter, in which he compared the konimeter method with the gravimetric method, and I, too, would like to add my quota of praise to the excellence of the paper.

No doubt some, I may say most, of the conclusions arrived at are correct. It would, however, to my mind, be a pity if the impression created by this paper, namely, that axial water-fed machines were creating just the very dust we are all so very anxious to kill (dust of less than the size of 5 microns), were to go unchallenged. It is felt that the matter is not yet well understood, nor has it been thoroughly investigated: no really reliable data are available on the subject, and the field for research is too large for any individual mine manager to undertake.

The industry is asking for a thorough investigation of the whole subject by the Miners' Phthisis Prevention Committee, and, to my mind, judgment should be suspended pending the result of such investigation.

Axial water-fed machines were introduced in the mine with which I am connected as far back as 1913 and very soon, from just a very small trial, we worked up to 200 machines, and contrasting the state of the mines before their introduction with present day conditions, I think we are all agreed that there is a distinct and a most decided improvement as regards dust conditions; and this stands to reason, because the dust is being killed at its source.

I, too, have many men who have been working these machines for four and five years, and am sure that none of them will grumble at present day dust conditions. Many of these men have assured me personally that their health is not suffering. There is little doubt that in order to get practically dustless results from that class of machine, certain conditions must be observed, such as the correct mixture of air and water, and also their correct relative pressures. There is not very much known on the subject just now, but, in connection with the few tests I have made, I have found that one does get a condition where very little dust is shown; very little fine dust—that is, dust less than 5 microns. And then, also, there is the length of the tube, and the tightness of the water-fittings in the machines: in the hands of an expert and experienced man these can be adjusted to give the desired result.

As I have already stated, it is a subject for investigation, and the Association of Mine Managers has already approached the Miners' Phthisis Prevention Committee on the matter, and it is hoped that such Committee will lay down standard conditions to be observed in the use of these machines.

I should like to endorse Mr. Whitehouse's statement when he said that, before taking any further steps or passing judgment we should await further information.

The Chairman: I would like to ask Captain Carson if he has any experience with regard to the sugar test method?

Captain H. Y. Carson (*American Red Cross*): This paper is of special interest to me, because of the work which has been done by the American Public Health Association, of which I am a member, on breathing dust in quantities when contained in the air; and it is truly a very valuable contribution to the literature on the subject.

I find in the paper some splendid new ideas, and I am very glad to take a copy to study it more carefully.

We, in America, have studied dust problems from perhaps a different angle than that from which you have studied them here on the mines. It is a problem which is becoming more and more acute, in our larger cities especially. Take the Subway System of New York City as an example. We find millions of dust particles per cubic foot in the air of the tubes of the underground system there; and, upon investigating these and examining the dust particles under a microscope, we find a very considerable percentage of them to be small particles of steel, coming from the brakes, wheels, and rails. The physiological effect of such particles upon the lungs may be rather severe after a continued period of breathing, at least, it might be one of the causes for our epidemics of influenza in New York City. Some investigators go as far as to attribute this as one of the causes of influenza that is the continued breathing of these sharp dust particles. At any rate, there seems to be a growing need for an accurate apparatus—not an accurate apparatus, perhaps, because none is likely to be accurate—but a good apparatus for measuring comparatively the dust particles in the air. However, your reason may be a little different to ours, but, nevertheless, as pointed out here, there is good reason for getting some comparative data on the air we breathe. The simplest method seems to be to use a direct instrument such as you have developed here, and which, by the way, is somewhat similar to the one developed by Dr. Hill of the Health Department in Chicago. That instrument you will find described in the Proceedings of the American Public Health Association during its last meeting, I believe. It has always seemed to me that an instrument which gives a direct reading is better than one which has to interpose a medium, such as sugar, and therefore to interpose many complicated factors into the final result; and, I believe I am safe in saying that in America, the article which gives a more direct reading is the one which seems to be most favoured to-day.

I am very glad indeed to have had this opportunity of hearing this discussion, and to take away with me this record.

The meeting then terminated.

Correspondence and Contributions.

GOLD ABSORPTION BY COPPER AMALGAMATION PLATES

In connection with cleaning up old mills after permanent shut down, the following data on this subject has recently been obtained, and is herewith published by Rand Mines Metallurgical Department.

From (A) Mill.—

A plate weighing 565 lb. (approximately 5 ft. 6 in. by 12 ft.) was first steamed, then scoured. It was then scaled by application of chemicals and heat. The gold-copper scale obtained, contained 12 oz. fine gold, or 12·17 oz. per ton of plate. After scaling, the plate was melted into an ingot, which assayed 3·75 oz. fine gold per ton.

Total fine gold in plate after steaming and scouring:—

In scale, 12 oz., or 12·17 oz. per ton.
In ingot, 1·05 oz., or 3·75 oz. per ton.

13·05 oz.

The above is from a plate after 20 years of service as primary plate.

From (B) Mill.—

The plates were first steamed and scoured; then scaled as in (A) Mill, with the following result:

PLATES 5ft. 6in. by 12 ft.	Weight of Scale.	Weight of scale after acid treatment and melting.	Fineness of Bar.	Fine oz.
4 Battery (Primary)	518 oz.	130 oz.	710·0	96·20
12 "	1616 oz.	316 oz.	886·5	280·01
5 Tube Mill (Secondary)	477 oz.	83 oz.	872·0	72·38
21	2611 oz.	529 oz.		448·59

Average yield per plate = 21·36 oz.

The scale was refined by acid treatment, using sulphuric acid and nitre. The above plates had been in use at least 20 years.

F. WARTENWEILER.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

MANUFACTURE OF MANGANATES.—"The *Engineering and Mining Journal* of October 27 contained a paper credited to Messrs. Ralston and Yundt regarding 'Chemicals Used in Flotation.' The paper is highly educational and interesting and indicates practical knowledge. I would call attention to the subdivision 'Manganates and Chromates Are Used for Differential Flotation.' Here the authors, after stating the facts regarding the practice, discuss the costs and suggests a means of preparing the manganates, which suggested method I consider in error and misleading. A similar error is found in German literature with a considerable number of incorrect statements regarding the manufacture of manganate salts.

Let us assume that the permanganates are under discussion as the oxidising agent desired, as they carry the double oxidising power and are stable where the simple manganate salts are unstable except in strong alkaline solutions. The potassium salts alone give the convenient crystal form, and no sodium salt or evaporated powder can be prepared without, say, 30 or more of alkali or NaOH present. Manufacture of permanganate salts was formerly exclusive with Germany, with a price per pound of potash crystals under 25 cents. Since the war prices have jumped to $1 or a little less for sodium-permanganate solutions of equal oxidising power, but carrying a large proportion of soda salts as chloride or sulphate of soda. This sodium permanganate is made in New York and used in mill and Government work as a temporary expedient until a better product can be obtained. The method of manufacture used is what is called the chlorate method. This condition, and statements of manufacturing chemists who have seen German practice, warrant the conclusion that the manganate roast is a rather difficult operation and that German means and apparatus are impracticable and too expensive for American adoption.

The authors state that the fusion of manganese dioxide and carbonate of the alkali will produce manganate, presumably the simple manganate which could be oxidised to the per salt. Practically this statement is untrue, as the reaction,

$$MnO_2+2K\text{ (or }2Na)OH+O = K_2\text{ (or }Na_2)MnO_4+H_2O,$$

shows that oxygen is essential, which the fusion act denies. It is academic that if a large excess of alkaline carbonate be used, adequate to form a fluid mixture with MnO_2 and the mass be heated to about 1,000° C. and air be blown through the fluid mixture, one will get manganate. The operation is utterly impracticable in a technical or economic sense because of the temperature and the immense volume of alkaline carbonate or resulting hydrate entering the leached solutions (several times the normal amount) and defeating the permanganate act to follow.

The only practical result of a fusion of MnO_2 and Na_2CO_3, using the large excess of the caustic adequate to enable fusion, would be that on adding such fused product to a flotation bath MnO_2 would precipitate and the alkali go into solution. Even if the fused mixture were blown with air to form the manganate Na_2MnO_4 the flotation solution, not carrying a strong alkalinity, such as 5% to 7%, would decompose the manganate into MnO_2 and the alkali.

The statement of Messrs. Ralston and Yundt I consider incorrect, and impractical if it were true. With the German apparatus the oxidising roast to manganate is exceedingly delicate and other apparatus has not been perfected to compete with the German in any practical sense. Because of the mis-statements made concerning manganate manufacture, I deem it best to correct the misunderstanding. I speak after having spent some months in the research of the subject."—P. C. CHOATE—*Engineering and Mining Journal*, Dec. 1, 1917, p. 962. (H. A. W.)

AN AVAILABLE SOURCE OF POTASH.—"*An Experiment.*—If any common variety of orthoclase or microline felspar be dry crushed to 100 mesh (I.M.M.) in an iron mill and mixed with its own weight of pure dry common salt and then heated to 900—1000° C. for two hours out of contact with air or moisture, or furnace gases carrying such air or moisture, a remarkable reaction occurs.

The sodium of the salt displaces the potassium of the felspar strictly according to the equation:

$$2NaCl + K_2O.Al_2O_3.(SiO_2)_6 \longrightarrow Na_2O.Al_2O_3.(SiO_2)_6 + 2KCl.^{*}$$

If the temperature has not exceeded 1000° C., and if moisture and air have been carefully excluded, the product will be found to consist of finely divided insoluble sodium felspar (albite) and a mixture of quite neutral and freely soluble sodium and potassium chlorides. These chlorides may be readily lixiviated in water and are easily separated from each other by fractional crystallisation.

The extraction of potash obtainable by this means from a sample of felspar carrying upwards of 10% K_2O will be in the neighbourhood of 85% under the conditions above stated. There is no loss by volatilization, and the weights of residue and salt will be found to correspond with the equation.

The experiment can be carried out in a large porcelain crucible (covered), or equally well in a sealed iron or nickel receptacle. Metals are not attacked so long as air and moisture are absent. These containers may be heated in an ordinary assay muffle for the experiment. If metal containers are used, it will be found that only on the outside of the vessel is there any attack, and this is due to air in the muffle. If air and moisture are excluded from the muffle, and a reducing or inert gas substituted, the containers will be very durable.

A Prior Invention.—The author of this paper has independently discovered and somewhat exhaustively studied this reaction and has worked out a practical process based on it, but he desires to give credit of priority for the discovery of the displacement of potash by soda obtained from salt to E. Bassett, who, in 1913, patented in the United States and Canada a process based on the same reaction.

That this discovery of Bassett's did not lead to a technically successful result seemed to me very surprising. It is, however, of the utmost importance to a successful result that air and moisture should be excluded during the heating of the mixture of salt and ground felspar, and Bassett appears to have overlooked this point, going so far in his specification as to assert in every claim that air must be present. He also failed to realize that the reaction is an equilibrium reaction and consequently reversible, and that, therefore, the degree of extraction obtainable depends on several factors. In his specification one part of salt and two parts of felspar are the recommended proportions, and this mixture results only in an extraction of about 60% of the potash, even if air be excluded, whilst the admission of ordinary moist air occasions the loss of over 30% of both salts and of course a still lower extraction of potash. Bassett's patent has apparently never been put to work and was not applied for in this country or anywhere outside America." E. A. Ashcroft.—*Inst. of Mining and Metallurgy*, December 13, 1917, p. 2. (H. A. W.)

α-Benzildioxime (Reagent for Nickel).—"The authors have tested Atack's method for detecting and estimating Ni in which α-benzildioxime is the precipitant (cf. C. A. 7, 3291). The reagent is best prepared by warming a MeOH solution of benzil with powdered hydroxylamine hydrochloride and a few drops of HCl, the oxime being filtered off from time to time. It is applied in the form of a saturated alcoholic solution. For the separation of Ni from Zn or Mg, NH_4Cl is added; Mn is retained in solution by means of citric acid and hydrazine (to prevent oxidation); Cu is kept in solution by means of Rochelle salt, but only small proportions should be present. The Ni precipitate does not suffer loss of weight even at 180°.—H. Grossmann and J. Mannheim, *Ber.*, *50*, 708-11 (1917); *J. Chem. Soc.*, *112*, II., 391-2 (1917).—*Chemical Abstracts*, Dec. 10, 1917, p. 3190. (J.G.)

Rapid Method for Copper in Ores.—"Weigh 0·5 gm. finely powdered ore into a 250 cc. beaker, add 10 cc. concentrated HNO_3 and boil down to 5 cc. Add 10 cc. concentrated HCl and again boil down to 5 cc. Add 5 cc. concentrated H_2SO_4 and evaporate to fumes over the free flame, holding the beaker with tongs and at the same time rotating it. Cool a few minutes, add 10 cc. H_2O, make alkaline with NH_4OH, add 3-4 gm. $(NH_4)_2CO_3$ and heat for 2 minutes. Filter under suction and wash alternately with H_2O and with concentrated NH_4OH till no blue colour is noticed in the washings. Transfer the filtrate to a 250 cc. Erlenmeyer, boil off excess NH_3, add 10 cc. concentrated AcOH and boil for 1 minute. Cool and titrate with $Na_2S_2O_3$ in the usual way, having volume of solution about 100 cc. and shaking vigorously during titration. Time required is 0·5 hour."—E. Nyman, *Chem. Analyst*, *21*, 8 (1917). *Chemical Abstracts*, Dec. 10, 1917, p. 3191. (J. G.)

METALLURGY

Ammonia Leaching of Calumet Tailing.—"Before giving a detailed account of the process as finally applied, it may be well to give briefly some of the chemistry of the process. Oxide of copper or native copper with the free access of air, dissolves in ammonium carbonate to form cupric ammonium carbonate, probably according to the following reactions:

$$Cu + O = CuO$$

$$CuO + (NH_4)_2CO_3 = CuCO_3.2NH_3 + H_2O$$

This cupric ammonium carbonate, in the presence of native copper and without free access of air, is reduced to the cuprous state as follows:—

$$CuCO_3.2NH_3 + Cu = Cu_2CO_3.2NH_3$$

This cuprous ammonium carbonate, in the presence of air oxidizes rapidly to the cupric state, and as such is capable of dissolving a further amount of copper. Now either the cuprous or cupric ammonium carbonate, when subjected to boiling or distillation with steam, loses its ammonia and carbonic acid gas, both of which can be absorbed in water and recovered, and as these are driven off, the cuprous or cupric oxide is thrown out of solution either as a heavy powder or as a scale, according to this reaction:

$$CuCO_3.2NH_3 + H_2O + Heat = CuO + (NH_4)_2CO_3$$

If these reactions are followed through, it will be found that the solvents are quantitatively regenerated and that the only consumption of a chemical element is that of oxygen from the air. Not only is this theoretically the case, but it was demonstrated in the experimental work on Calumet conglomerate ore that these reactions did take place about as indicated and it was possible to make a

---

[*] In modern terminology this equation would read $KAlSi_3O_8 + NaCl \rightleftarrows NaAlSi_3O_8 + KCl$—Ed. Com.

recovery in the laboratory of practically 100% of the ammonia. This was done, however, by heating the tailing after the copper had been dissolved and the sand washed—an operation which of course is impracticable. The amount of ammonia remaining in the tailing before heating was small enough to assure the economic possibilities of the process.

It will be observed from the reactions that the solvent is cupric ammonium carbonate and that this is reduced to the cuprous state in dissolving the native copper. To reoxidize this solution and restore its solvent power, only oxygen of the air is used, and the success or failure of the process depends upon the ability to oxidize the solutions quickly and without loss of ammonia. It is impossible to work entirely in enclosed vessels because to do that would prevent oxidation, and on the other hand to work entirely in open vats is impractical not only because of the smell and discomfort, but also because it is almost sure to result in excessive loss of ammonia from volatilization. In working with a single vat, as was done in the experimental plant, it is easy to get sufficient oxidation of the solution by superficial action in the storage vats, for the cuprous solutions have a great avidity for oxygen, and since the cupric salt formed is heavier than the cuprous, convection currents are set up that aid materially in the complete oxidation of the cuprous solutions. It was realized that in a large plant where the effluent solution from one vat would be in storage for only a limited time before being used again as a leaching solution, there would be much less opportunity for oxidation. However, this was worked out as the size of the plant increased, and we have found it a simple matter to oxidize the leaching solutions by blowing through them and to absorb what little ammonia gas is driven off with the air in a wash solution. This particular feature, which caused the most concern in experimental work, was thus easily met as the plant developed.

The other matter that caused a good deal of difficulty in the experimental work was the boiling-out of the solution. The oxide of copper as it was thrown down in the laboratory was a very fine powder which settled rapidly. It was hoped that on a large scale this powder might stay in suspension with sufficient agitation and then settle into a pocket and be easily removed by means of a trap discharge. What was actually found, however, was that while a part of the oxide could be handled by the foregoing methods, that part of it which had an opportunity of becoming superheated, as it would above the solution level, formed a scale so hard that it could be removed with nothing short of a hammer and chisel. It became evident that in order to distil this copper ammonium carbonate continuously would require a type of still different from anything on the market, and we set about making our own apparatus. We started out with a still consisting of twelve cylindrical sections, each 15 in. in diameter and 4 in. high and with a vertical shaft extending the full length of the still, fitted with a scraper for each section. The general principle of operation was similar to that of any continuous still, the solution passing downward from section to section against the ascending current of steam. This apparatus demonstrated that any scale of copper oxide formed could be handled by means of these scrapers, and a second still, 36 in. in diameter, was built, followed by the present commercial stills 84 in. in diameter. They have a capacity of over 150 cu.m. per day of copper ammonium carbonate solution assaying about 20 gm. NH_3 per litre, and the same in copper.

The material treated in the present leaching plant consists of mill tailing as free from copper as the mechanical processes and water concentration will permit. A part of the material comes from the current tailing from the mine rock and a part of it from corresponding tailing that has been in Torch Lake for many years. No matter what the source, this material had been originally put through 3/16th in. screen in a steam stamp and is now further ground in pebble mills to pass a 28 mesh screen. This product is then concentrated upon Wilfley tables, and it is the tailing from these tables that enters the leaching plant. In this leaching plant the feed, or heading, is lead to 16 V-shaped settling vats, each 19½ ft. long, 10½ ft. wide and 6½ ft. deep. The overflow from these settling vats contains practically all minus 200-mesh material and is at present a waste product, although plans are under way to treat it by flotation. The thickened product from these V-vats is drawn off by means of plugs and led to eight quadruplex Dorr classifiers, the slimes from which go to waste and the sands to leaching vats. This classified product is an ideal one for leaching, and while it carries some slime, it has not been found necessary to observe any of the precautions sometimes taken in sand-leaching processes for eliminating all traces of colloids. There seems to be no serious obstruction to a satisfactory leaching gate.

The leaching vats in the present building are eight in number and arranged in two rows. Above each row there is an 18-ton travelling crane. The vats are of steel, 54 ft. in diameter and 12 ft. high, and are provided with removable covers. The joint between the cover and the vat is water-sealed and is made by a channel on the cover projecting into a water-filled annular launder. The covers are supported by the sides of the vats themselves, and there is sufficient headroom over the vats to permit three covers being piled one on top of the other so that the crane can move the distributor or cover over a vat which is covered and which has upon it the cover of an adjoining vat. There is but one outlet for solutions, and that is in the bottom of the vat, near the centre. On the inside of the vat at the top is the overflow launder, from which there are six outlets. This launder, during the leaching process, has its outlets plugged and is used to form the water seal for the cover, as already indicated. In order to drain the water rapidly from the sand after filling, there are provided two 6-in. decanter pipes. There are seven discharging doors for sand in each vat, six along the sides at the bottom and one in the bottom at the centre. The centre gate is operated from above by means of a rod that extends up through the centre column of the vat. The centre column acts also as a support for the sand distributor, of the Butters and Mein type, which cannot be hung from above, as in the usual leaching vat, because of the clearance necessary for the cover. These leaching vats are carried on 12-in. I-beams which in turn rest on concrete cross walls of sufficient height to permit ready access to and inspection of all parts of the bottom. The vats are provided also with a platform or runway 3½ ft. below the top, which forms the main working floor.

The method of distributing the sand is of interest. The main distributing launder runs the length of the building, and in the centre between each set of four vats discharges into a distributing box that can be closed off by means of a tipple. This tipple is pivoted at the low point of the launder and is capable of being raised and lowered. Each distributor box is fitted with four outlets which are in turn provided with rubber-gasketed cast iron gates. The gates, when open, permit the discharge of material into a portable launder extending from the distributor box to the hopper of the vat distributor. By means of the tipple already mentioned, and the two distributor boxes with their four gates each, it is possible to divert the feed to any vat.

For supporting the sand in the vats a filter grating of wood is provided, and a filter consisting of a lower layer of coco matting over which is 8 oz. duck. The coco matting and the duck are held in place of caulking them with hemp ropes into grooves around the centre gate casting and also around the periphery of the vat. After a year of use the first set of filter cloths and matting is still in commission and shows no great evidence of wear. The details of these filters are similar to those used at the Homestake Mining Co., at Lead, S.D., and we are indebted to Allen J. Clark, of that company, for their design, which has proved eminently satisfactory.

For storing the leaching solutions and the wash there are at present 18 steel vats, 22 ft. in diameter and 11 ft. high. For storing the concentrated solution of ammonium carbonate, as purchased or distilled, there are steel vats with a total capacity of about 200 cu.m. In addition to this, there is a mixing vat 16 ft. in diameter and 1 ft. in height, in which one of the leaching solutions is made up to strength, and also constant-level vats at the highest point of the building so as to give gravity flow under a constant head.

There are four ongoing solutions as follows:— First leach, second leach, first wash and second, or water wash. There are four corresponding effluent solutions: Rich solution for distillation, new first leach, new second leach and new first wash. The rich solution, first leach and the ongoing second leach will all assay about 20 gm. NH_3 per litre, with copper content respectively of about 18 gm., 12 gm. and 9 gm. per litre. These assays are subject to some change, depending upon the copper content of the sand and upon the exigencies of operating conditions. The process is controlled by analysis of the copper and ammonia in the leaching solutions, and the aim is to keep these constant. To do this requires vigilance and necessitates regenerating by distillation a volume of solution containing copper equivalent to the amount extracted from the sand.

The general operation is as follows:—The sand, as it leaves the Dorr classifiers, is diluted with about four times its weight of water and run into the sand vats through the distributor until the charge has reached the desired height. During this operation the excess water overflows from the vat, and the launders are so arranged that the bulk of this water can go back to the discharge of the Dorr machines as conveying water. When the vat is full, the water is drained off as rapidly as possible by means of the decanter. With the aid of a valve in the solution-outlet pipe, discharging to waste, the sand is drained until the surface is firm enough to work on. As the water goes down, any irregularities of the surface are evened up by poking the sand with sticks, which tends to break up all ridges and has no harmful effect upon the rate or uniformity of percolation. What little slime is left remains on top of the settled surface as a very thin film, and this is broken up by means of a garden rake. The decanter-pipe covers are again put on, likewise the plugs in the overflow pipes, and the overflow launder is filled with water to form the seal. The vat cover is put in place, and the vat is ready for leaching. With the waste valve open, the first leaching solution is led upon the sand as rapidly as possible and displacement of the water by the pregnant solution begins. After a period of about 2½ hours the first traces of ammonia appear at the waste valve, which is then immediately closed and circulation through the effluent leaching-solution piping begun at the normal percolation rate. The first portion of the solution coming through is naturally low in copper and ammonia, owing to diffusion and imperfect displacement, and is run into the second leach. This solution builds up very rapidly, however, in copper and ammonia, and the subsequent course of the cycle, so far as effluent solutions is concerned, is determined by conditions existing, it being essential that the first and the second leaching solutions be maintained at their proper assay, and the amount of rich solution drawn off for distillation is governed accordingly. Naturally, over a series of vats the amount of copper in this rich solution is equal to that extracted from the sand, but it may vary considerably from one vat to another. The aim is to have this rich solution for distillation as low in volume and as high in copper as possible, for the distillation is an important item in the total expense and the volume distilled is maintained at a minimum. As soon as the desired volume of first-leaching solution has been run on the sand, the second leaching solution is run on in the same manner, and after this is drained below the surface of the sand, it is followed by the first wash and this in turn by the second wash, which is water. The volume of water added to the cycle at this point is equal to the amount removed by distillation. This is the invariable practice so far as the ongoing solutions are concerned, although the quantity of these solutions is occasionally varied to suit the feed. The effluent solutions are not regulated with quite the same nicety, as they are affected, not only by conditions within the sand vat itself, but more particularly by the volume and assay of the solutions in storage. In general, one may say that the solution first coming off goes to the second-leach vats until built up in copper and ammonia, after which the rich solution for distillation is drawn off. This is followed in turn by the full volume of the first leaching solution, this by the remainder of the second leaching solution and finally by the wash. This completes the leaching cycle proper, which in the ordinary operation requires about 70 hours. The vat is then flushed out through the seven gates provided for that purpose, by means of two high-pressure streams and some low-pressure water, this being completed ordinarily in 3 hours. With the 12 hours allowed for filling, the entire operation is accomplished within 90 hours.

Before describing the distillation process, it may be of interest to explain how the leaching solutions are made and controlled. The only solvent required is purchased in liquid form, and thereby some of the difficulties attendant upon dissolving a solid for use as a solvent are avoided. We purchase carbonated ammonia liquor in vat cars from the Semet-Solvay Co., of Syracuse, N.Y., shipment being made from the company's Detroit plant. The amount of carbon dioxide in this liquor is varied by us so as to keep the percentage in the leaching solutions about the equivalent of that of ammonia. The railroad track comes directly into the leaching plant, and the contents of the vat car are forced by means of compressed air into the strong-liquor storage vats and from these run by gravity into the mixing vat at the desired rate for maintaining the ammonia contents of the second leach. All other solutions are made up from the effluent solutions by proper selection and control. If there is any tendency for the volume of any given solution to increase or decrease, or its assay to vary, it can be compensated by varying the amount of solution to be distilled. There is absolutely no fouling of the solutions, and there is never any necessity for throwing away any portion of a leaching solution or of a wash. The total volume of all ongoing solutions and of the effluent rich solution is measured by means of recording V-notch meters, and the rate of flow of the effluent solutions from the individual sand vats is indicated by means of gauges connected to Pitot tubes and by measurements of the solution-storage vats. These means, in connection with hourly assay samples, have been found ample for complete control of the leaching solutions and of the cycle.

Distillation of Pregnant Solution.—The distillation of the rich solution with the recovery of the ammonium carbonate and the precipitation of the copper oxide is carried on in an apparatus analogous to that used in the by-product coke industry for distilling ammonia, with the exception of the still previously described, which was developed for this particular liquor. The plant for this distillation was designed by us in connection with the engineers of the Semet-Solvay Co., who furnished all the apparatus except the stills mentioned and their accessories. About 90% of the copper content of the liquor is deposited in this still, which we call a roughing still, and is trapped off into a chamber that is discharged periodically directly into a filter box and from this loaded into concentrate cars. The other 10% of the copper remains in solution or suspension and passes through a second still of a standard type, which we call a finishing still, and from which the final solution, barren of ammonia, runs into a settling vat to permit the settling out of the copper oxide. There are two roughing stills connected in parallel, as to solution and steam, with one finishing still, and the rest of the distillation unit is made up of a reflux column, condenser, etc. The oxide of copper as precipitated by this operation will assay about 80% copper and is practically pure. It goes direct to the smelting works, where it is mixed with the native copper concentrates, and as such, since it is free from gangue, it is highly prized by the smeltery men, since the oxygen it contains aids in slagging off the impurities of the rest of the charge.

As at present operated, the daily capacity of the leaching plant is 2000 tons. The plant is run by three shifts of eight men each, and in addition to these there are six men on the day shift for repair work, the bulk of which is in connection with the stills. These with the head chemist make up the working force. Allowing an average rate to these men of $3.50 per day, there is indicated a labour cost of 5 cents per ton of material treated. The repairs will be very slight, judging from the ten months of operation of the plant. The wear and tear on Dorr classifiers is not appreciable as yet, and the same is true of the sand distributor. Centrifugal sand-pump liners give some trouble, but nothing that cannot be easily handled on the Sunday morning shutdown. There has been no evidence of corrosion in the cast-iron solution pipes or in the leaching vats. The strong liquor as received and the distillate made is somewhat corrosive, but hardly sufficient to warrant a protective lining. Fortunately, the extent of this strong-liquor line is limited and its maintenance will not become laborious. The amount of electric power consumed in the plant is equal to 225 kw., most of it being used in the operation of sand pumps which, on account of the local conditions, are numerous, since it is necessary to pump the mill tailing into the leaching plant, to pump the sand from the Dorr classifiers to the leaching vats and also to pump the tailing from the plant back to the lake. The steam for distillation amounts to about 35% by weight of the liquor distilled and, as now operating, costs about 4 cents per ton of sand treated. The greatest single item of expense is the ammonia, the loss of which is just under 1 lb. per ton of sand treated. Under ordinary economical conditions this ammonia should not cost over 15 cents per lb., but at present, owing to the excessive demand, the cost is almost double that figure. The complete record of cost for March is given in the accompanying table.

Cost of Ammonia Leaching.

	Per ton.
General expense, including foremen and chemists	$0.031
Ammonia	.255
Sand conveying and classification... . .	.020
Labour, power and supplies for leaching .	.027
Steam for distillation...	.038
Labour and supplies for distillation .	.035
Total cost	$0.406

During this month there was a recovery of 8·18 lb. copper per ton of material treated, giving a cost per pound, up to smelting, of just 5 cents. For the first four months of the year the cost per pound of copper has been less than 4.75 cents up to smelting, or about 6 cents per pound sold. The present production is at a rate in excess of six million pounds per year.

The extraction varies with the fineness of the product, which so far as the leaching plant is concerned, should all be through 48 mesh, but which actually is very much coarser. As operating at present, there is some 28- and 48-mesh material on which the extraction is less than 60%, whereas on the material passing through the 150- and 200-mesh the extraction is as high as 85%. The average extraction is now about 75%. The data in the accompanying table are for April.

Sand Leaching Plant, April, 1917.

	Feed		Tailing		
Size of Sand Particles	Sand	Cu	Sand	Cu	Extraction.
On 28-mesh .	3·6	0·707	2·1	0·416	29·7
28- to 48-mesh ..	18·3	0·619	16·9	0·214	65·4
48- to 100 mesh...	14·0	0·607	46·0	0·136	77·6
100- to 200-mesh .	24·2	0·575	25·1	0·094	83·7
Through 200-mesh	9·9	0·994	10·8	0·114	88·5

The process was originated and developed entirely by Calumet & Hecla, engineers. The mechanical details were designed by H. E. Williams and Robert MacIntosh, with helpful suggestions from Allan J. Clark, of the Homestake Mining Co. The general design of the plant and the chemical development of the process was taken care of by the writer and H. C. Kenny, the latter now in charge under Henry Fisher, mill superintendent."—C. H. BENEDICT.—*Engineering and Mining Journal*, July 14, 1917, p. 13. (H. A. W.)

Abstracts of Patent Applications.

154.17. Henry Charles Wesson Brown. Improvements in atomising spray. 29.3.17.

This application refers to an atomiser for a spray of water in which a jet impinges upon the blades of a wheel free to revolve.

161.17. Leendert Janse. Sliding Door. 14.8.17.

The above application relates to a new system of sliding door, and has for its object to provide a door of simple construction which can readily be quickly opened and closed. In this connection it has particular reference to lift cages.

755.17. Michael Henry Baker. Improvements in concentrating or slime tables. 30.11.17.

This application relates to a special form of construction of concentrators of the Wilfley type, and claims the form in the construction of which the frame of the table is supported upon comparatively long loose rollers retained in chairs fixed upon the under carriage of the machine.

765.17. Quintin Moore (1), James Cunningham (2), J. W. B. Stokes (3). Improved process and apparatus for the production of recoverable ammonia in the manufacture of producer gas. 10.12.17.

This application relates to an improved process and apparatus for the production of recoverable ammonia in the manufacture of producer gas. The producer is arranged so that the fuel is treated in three zones of different temperatures, and the steam is so regulated as to give the best recovery of ammonia without the disadvantage of excessive steam.

The process is only claimed in its particular application in the manufacture of producer gas. The claim for the apparatus is only as regards its dimensions in so far as the measurements of the producer are specifically proportioned for carrying out the process: it is of unusual length relative to its area.

791.17. Nitrogen Products Co. Improved electrical process for producing cyanides.

This patent application is for an improved electrical process for producing cyanide, namely, the fixation of nitrogen to form cyanogen compounds by the interaction of alkali or alkaline earth compounds, and carbon with nitrogen, in the presence of a catalyser, for instance, iron.

8[illegible].17. Hans Foersterling (1), Arthur Ludwick Halvorsen (2). Process of extracting values from ores. 15.12.17.

This application claims a process and apparatus patent for extracting values from ores containing gold, silver or copper, etc., the principal objective being to provide a process for recovering metals by treating ore so that all the metal content of the ore is obtained simultaneously. It is in reality a precipitation process utilizing the fairly well known solvent NaCN, and recovering the dissolved values through the medium of mercury and metallic sodium.

The apparatus consists of a cylindrical casing of steel plate; an axis being centrally situated in journals and protruding on either sides of the casing. The axis bears a closed drum on which, at small intervals are annular plates of steel with perforations for the passage of the solution. When in operation this internal arrangement is rotated, causing vigorous agitation of the solution flowing through the apparatus.

11.18. J. Tylor & Sons, Ltd. (1), James Gaunt (2), Douglas Brookfield (3). Improvements in smelting furnaces and the like. 22.1.18.

This application relates to improvements in melting furnaces, and consists essentially in a particular method of pre-heating the air blast by arranging circuitous conduits round the body of the furnace. Other claims are made for a hingeably attached ash pit, and an upward extension of the cover to form a hopper, in which the melting charge is also pre-heated.

13.18. Albert Edward Sainer. Improvements in rotary pumps. 22.1.18.

This application refers to a pump having a pendulum rotor, the stem of which slides between the flat faces of two segmental blocks resting in curved seats formed in the opposite walls of a radial extension of the pump chamber, an outlet for the fluid formed by a channel extending longitudinally through the stem of the pendulum and opening into the pump chamber at a point in the stem adjacent to the pendulum bob, and a port at the end of the radial extension of the pump chamber, as described and shown.

An arrangement of pumps as claimed in claim (1) wherein two or more pump castings are bolted together, and the driving shafts are coupled, substantially as described.

Changes of Address

BLEWETT, W., *l/a* Birmingham; c/o Kynoch, Ltd., Umbogintwini, Natal.
GALBRAITH, A. M., *l/a* Bertrams; 9, First Street, Malvern.
HAY, E., *l/a* Krugersdorp; P.O. Box 1242, Johannesburg.
MATTHEWS, E. L., *l/a* Benoni; Village Deep, Ltd., P.O. Box 1061, Johannesburg.
[illegible], D. F., *l/a* Germiston; New Unified G.M. Co., Box 5, Maraisburg.
O'HARA, J. D., *l/a* Nigel; City and Suburban G.M. Co., Ltd., P.O. Box 1026, Johannesburg.
ROY, J., *l/a* Nigel; New Modderfontein G.M. Co., P.O. Box 25, Benoni.
TOM, I., *l/a* Johannesburg; 95, Hatton Garden, London, E.C.
WEINREEN, M., *l/a* Johannesburg; Belleville, Albany Road, Sea Point, Cape Town.

APR 1 5 1920
UNIVERSITY OF T

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII MAY 1918. No. 11.

Proceedings
AT
Ordinary General Meeting, May 18th, 1918.

The Ordinary General Meeting of the Society was held in the South African School of Mines and Technology Building, Johannesburg, on Saturday, the 18th May, 1918, Mr. H. S. Meyer (Vice-President) in the chair. There were also present:—

32 Members: Messrs. H. A. White, H. R. Adam, J. Chilton, J. Gray, C. Toombs, F. W. Watson, John Watson, E. M. Weston, E. H. Johnson, W. R. Dowling, J. E. Thomas, Profs. G. H. Stanley and J. A. Wilkinson (Members of Council), H. D. Bell, T. N. Dewar, J. M. Dixon, P. Friedman, N. M. Galbreath, C. H. Greathead, E. G. Izod, A. H. Krynauw, E. J. Laschinger, T. G. Martyn, C. A. Meiklejohn, E. C. J. Meyer, P. M. Newhall, E. A. Osterloh, J. J. R. Smythe, A. L. Spoor, J. Thorlund, M. O. Tillard, and G. A. Watermeyer.

9 Associates and Students: Messrs. G. J. V. Clarence, J. Davidson, C. L. Dewar, O. A. Gerber, J. Gibson, E. G. Harding, J. Innes, H. L. Krause, J. S. Moir, and J. A. Woodburn.

30 Visitors, including Sir Harry Ross Skinner, and Fred Rowland, Secretary.

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 20th April, 1918, as recorded in the April *Journal*, were confirmed.

SCRUTINEERS FOR ANNUAL BALLOT.

The Chairman: It is the custom at the meeting preceding the Annual Meeting to appoint Scrutineers for the Annual Ballot for Officers and Council. I shall now be glad to accept nominations.

Mr. H. A. White *(Vice-President)*: I beg to nominate Messrs. S. Newton, A. Thomas, P. T. Morrisby, and E. A. Osterloh.

The nomination was agreed to *nem con*.

LARGE WHITE PEBBLE, EXHIBITED AT FEBRUARY MEETING.

Mr. John Watson, F.I.C., *(Member of Council)*. Some of our members have enquired further about this pebble. When our general manager returned from his annual holiday, I got his permission to break the large pebble across and assay one half of it. The assay was done in duplicate on portions of 2 A.T. each, and the beads parted gave:

	1.	2.	Mean.
Fine gold per ton	1·75	1·80	1·775 dwt.

On panning the remainder of sample, it showed a distinct tail of free gold and some isolated flakes. There was a little iron pyrite present; but no indication of lead chromate (as suggested by Mr. Rusden).

As I spent two months on Penhalonga mine, in 1901, I know the appearance of crocoisite ($PbCrO_4$). The tail was examined with a magnifying glass. The "show" of free gold in the pan might have led one to expect a higher assay value.

ASSAY SUPPLIES, AND THE UTILISATION OF SOUTH AFRICAN MATERIALS IN ASSAY OFFICES.

Mr. John Watson *(Member of Council)*: Lest anyone should think that I am biassed against the use of cement for the lower portion of cupels, I wish to state that since the April meeting I discussed the matter with my friend, Mr. Toombs. We tried afresh and are now making cupels, with the lower three-fourths of cement, which answer, so far, quite well.

Two years ago we used a short brass plunger like this (exhibited), which presses down the moistened cement in the mould, leaving a smooth cup-shaped cavity over which the mabor, or cupellite, was filled in before forcing down the steel plunger. The cupels made by this method, we tried and found unsatisfactory. We have now given up the use of these brass plungers and simply fill-in the cement, leaving it rough and irregular on the surface. A space of about quarter depth is left, into which the moistened cupellite is forced down by slight pressure of the hand, then the steel plunger is forced down.

The cement cupels, which we made formerly, had a tendency to crack and break, around the rim and cup, portions of broken cupel getting mixed with the assay bead. Now these cupels by the later method (leaving a rough line of demarcation between the cement and cupel-powder) have only been made within the last few weeks, but their tops remain sound and intact on using.

Mr. White suggested a drawing of the cupel machine. For this, I must refer him to Mr Kenneth L. Graham, as the Rand Mines, Ltd., and Central Mining and Investment Coporation made an arrangement with the patentee for the rights of using the machine. We shall be pleased to show ours to anyone who comes with the necessary authority.

Mr L. Colquhoun (*Member*): —We (B.S.A. Explosives Co., Ltd.) are not manufacturers of "chemically pure" acids, though the sulphuric acid we sell for accumulators is pure enough for many laboratory purposes. According to Mr. Watson, the chief source of waste in assaying is in the use of imported nitric acid for parting the cornets. If this be so, there is an opportunity for some economically minded assayer to test the commercial grade of nitric for this purpose. The harmful impurities (halogens and nitrous acid) are reduced to a negligible figure by boiling the strong acid for a minute or so, adding the required amount of water, and boiling again until the oxides of nitrogen disappear. This simple treatment will probably fit the commercial acid for assaying work.

Messrs. Kynoch, Limited, are now producing chemically pure inorganic acids (including hydrofluoric).

The Chairman: The contributions we have just heard are extremely interesting, and I can only commend them to your notice. In these days when we are all trying to save a bit all round, it is not very difficult or expensive to risk a little in experimenting.

THE FURNACE AS AN ADJUNCT TO THE SMITHY ON A GOLD MINE

Mr. R. Craib (*Visitor*): Owing to scarcity and abnormal cost of materials, considerable attention is being paid to the reverberatory furnace as an adjunct to the smithy, by which means forgings, stems, shoes, dies, etc., are made from scrap. Most mines along the reef have scrap-heaps which, in pre-war days, were looked upon as worthless, but to-day have become a valuable asset. Of course, scrap-heaps have a limited life, but by the time these are depleted we will then be in a more hopeful position to work the natural iron ore of the country.

A furnace was installed at the Simmer and Jack Proprietary Mines some four months ago, and was accompanied with the usual failures incidental to most new undertakings, which were mostly due to the uncertain temperature of this particular type of furnace. A great improvement was effected, however, by the addition of forced draught below the fire grate. This forced draught is produced by a jet of steam which injects air into a closed ashpit, and which can be regulated to suit any temperature required. The running cost of this furnace is £3 per shift of eight hours, which includes supervision, white and native labour, coal and steam. I am unable to state the maintenance cost as the furnace has not been sufficiently long in commission. The following is some of the work which has been accomplished by means of this furnace, and which would never have been attempted on the forge on account of the prohibitive cost:—

Battery Shoes.—Battery shoes which have had the shanks broken off are heated in the furnace, usually five at one time, and by means of hammer and die are reshanked. Sixteen shoes can be reshanked in this way during the shift. One hundred and fifty-two have been treated in this manner. It is also interesting to know that not one of these shoes so treated has broken. A novel method in making complete shoes is as follows, the material being two old cam bosses and one broken tappet. The tappet is cut in halves, which provides centre plugs for the cam bosses; each set is then welded, drawn down, and shanked, forming two complete shoes 9 in. × 10¼ in. in length. The time in making shoes in this way is 3½ hours each.

Battery Dies.—Battery dies are made from five old ones by placing one above the other, welding into a solid mass, and forming under the hammer. One complete die can be turned out per hour by this method. Another method of making dies is by cutting a broken tappet in halves and filling the centre holes with worn out shoes, this forms the material for making two dies. It is found that the life of these dies compares very favourably with that of the imported article.

Battery Stems.— Battery stems are made by faggotting small pieces of iron—the largest piece being not more than 14 lb. weight—and drawing down to the required diameter. Owing to the hammer serving this furnace being too small it is impossible to faggot a bloom sufficiently large to form one complete stem, therefore it is necessary to weld short pieces together. One complete stem was made by using the previous bloom as the foundation for the next, and in this manner an unwelded stem was produced at a cost of £7 10s. This stem is working at present, and apparently is of as good material as anything ever imported.

Bushes for Battery Heads.—Bushes for battery heads are very economically made by means of the furnace, as a great number can be heated at one time.

The above is some of the work directly connected with the mill which has been accomplished by means of the furnace, and which has more than repaid the initial outlay in building the furnace.

Not only has the furnace been of value to the mill, but has actually become a necessity to other departments, and all our smaller forgings in future will be made from faggotted iron produced on the property.

One complete set of loading box forgings was made from this iron a few weeks ago, which previously had always been made from mild steel, or "Lowmoor" iron, on account of the number of square holes which had to be punched in them. The faggotted iron stood the test of forging splendidly.

Two tons of scrap iron was made into chair-plates for 60 lb. rails; this, by the usual method, would have been impracticable on account of cost.

The furnace has also been of service in the annealing of skip connections, such as draw-bars, shackles, pins, etc., giving the article an even temperature, which cannot be procured by means of the forge.

Boilermakers also welcome the aid of the furnace in flanging, dishing and working of plates. A very smart piece of work was performed the other day in the dishing of a $\frac{3}{4}$ in. plate to form the rose of an 8 in. foot valve; this job was completed in five hours, which in the ordinary way would have taken three days. Sixty pieces of 1-16 in. plate, 14 in. in diameter, were flanged to a depth of 1 in. by means of furnace, die and hammer in five hours, this also would have been a laborious task by the usual method.

The faggotting of wire ropes has not been as successful as was anticipated on account of slight flaws in the apparently solid bloom, and this also applies to the faggotting of broken jumper steel. A few of the "jack-hammer" pistons which have been made from these blooms, however, show that in all other respects that this would be splendid steel for the purpose. Probably when production in quantity is called for a remedy will be found to overcome this difficulty.

That the furnace is of value to the shops is shown by the following conversation which took place the other morning:—On asking the shop foreman where we were likely to find a piece of steel to form a crankpin, the sizes being 24 in. long by 10 in. in diameter, and weighing approximately 500 lb., I was met with the answer, "Get Hampton (foreman smith) to faggot a piece."

I am indebted to Mr. C. D. Leslie, of the Consolidated Goldfields, for permission to publish this article.

The Chairman: At this stage of the proceedings I find I must apologise, when I see such a large audience, for having omitted to welcome our numerous visitors here this evening, and I must also congratulate our members on the sudden awakening of interest in the Society's proceedings.

I am sure we must congratulate Mr. Craib on his ingenuity and the able manner in which he has tried to face the difficulties with which we are to-day confronted, and you will be very glad to hear a little criticism or addition to the discussion from our engineering friends present this evening.

Mr. E. J. Laschinger *(Member):* Without wishing in any way to detract from the value of the note which has just been read, I would like to point out that a similar kind of furnace to that described has been in use at various mines for some time past, more particularly the one at the City and Suburban, which has been in operation for the past two years. The furnace has been used for heating up scrap to be worked up, for faggoting and for annealing.

Mr. E. M. Weston *(Member of Council)*: With regard to re-shanking shoes, I believe Mr. Tom Bell, the foreman blacksmith of Randfontein Central was the first one to do it on the Reef.

Mr. H. A. White *(Vice-President)*: I would just like to remark, on behalf of the technical societies, that our interest is not strictly confined to gentlemen who actually originate an idea, but is mainly directed to the gentleman who comes along here and gives us a description of it.

The Chairman: If there is nothing further to be said on this subject at this meeting, I hope the subject will not be dropped altogether. As Mr. White very aptly states, it is the man who comes along here and helps his fellow worker in the industry who gets the best welcome in this Society

CEMENTATION PROCESS APPLIED TO MINING (FRANÇOIS SYSTEM)

By A. H. Krynauw (Member)

Introduction.—In bringing this paper before our Society, I must ask the indulgence of members for dealing with a subject with which I have but a short acquaintance, and consequently only a limited experience. The greater proportion of my knowledge on this matter is the result of perusal of literature on the subject, and personal explanations so kindly and freely given me by Mr. François, the initiator of the François Cementation Process. My plea, therefore, for introducing the matter at this stage is that so important a process should be considered by engineers on these fields as early as possible, so that by combined efforts the mining industry on the Rand may be benefited by a process capable of very considerable application, and of undoubted economic and practical value.

During recent years experience has proved that cement can be introduced, under pressure, into the minutest fissures and cracks in rock strata, as well as cracks and interstices in masonry and concrete constructions, and made to set there. This practice of introducing cement grout under pressure has evolved to that known to-day as the François Cementation Process. An essential condition in the introduction of cement into fissures and cracks is that the injection should be done under a considerable pressure, the object being, firstly, to overcome the contra pressure of water present in the fissure; secondly, for the purpose of forcing the cement as far as possible into the minute cracks, and, thirdly, for the purpose of squeezing out the superfluous water from the cavity which is being filled with cement pulp, and thus leave the cement in a condition most suitable for its rapid and efficient setting

A series of very interesting experiments bearing on the subject of the setting of cement under various conditions has been carried out, and, briefly, we find that while cement milk when allowed to set ordinarily under water, does so only very slowly and reluctantly, the same milk when subjected to pressure, such as produced by a specially constructed cementation pump, sets hard within 24 hours. As everybody present doubtless knows, the setting of cement is chiefly due to the inter-crystallization of hydrated calcic silicate and hydrated calcic aluminate, just the necessary amount of water being taken up to complete the crystallization, the crystals growing together and forming a hard mass. Now, when a superabundance of water is present, such as in the mixture used in cementation work, these crystals ordinarily seem reluctant to inter-crystalize, consequently the setting of the cement is very slow and incomplete. As it is obviously impossible to inject cement in the form of thick paste, the condition most suitable for hard setting in the shortest time, we were anxious by experiment to find the probable reason for the hard setting of the cement when pumped under pressure into fissures, etc., as is shown by the cores of cement obtained when a filled fissure is penetrated by subsequent drilling operations. After many experiments we feel certain that what happens in practice is much as follows:—First of all the constricted exits of the fissures are choked with cement pulp, which forms a filter bed on which successive layers of cement are deposited, the surplus water being squeezed out through the cement filter already formed in the peripheral areas of the fissure or cavity. As more cement solution is injected the pressure gradually rises, and goes on rising owing to the fact of the water having to be squeezed through an increasing thickness of cement filter. The successive layers of cement finally completely fill the fissure or cavity, leaving the cement in a condition suitable for its complete and good setting. Pressures of 1,000 lb. to 4,000 lb. per sq. in. are used, and for this purpose the following specially designed pump is employed. The pump is of the double ram horizontal type with a 12 in. stroke, the steam end having a diameter of 14 in., and the water end a plunger diameter of from 1⅝ in. in some pumps, to 3 in. in others, depending on the final pressure likely to be required. As the wear on the valves is great, hardened steel balls are used, these being found to last best.

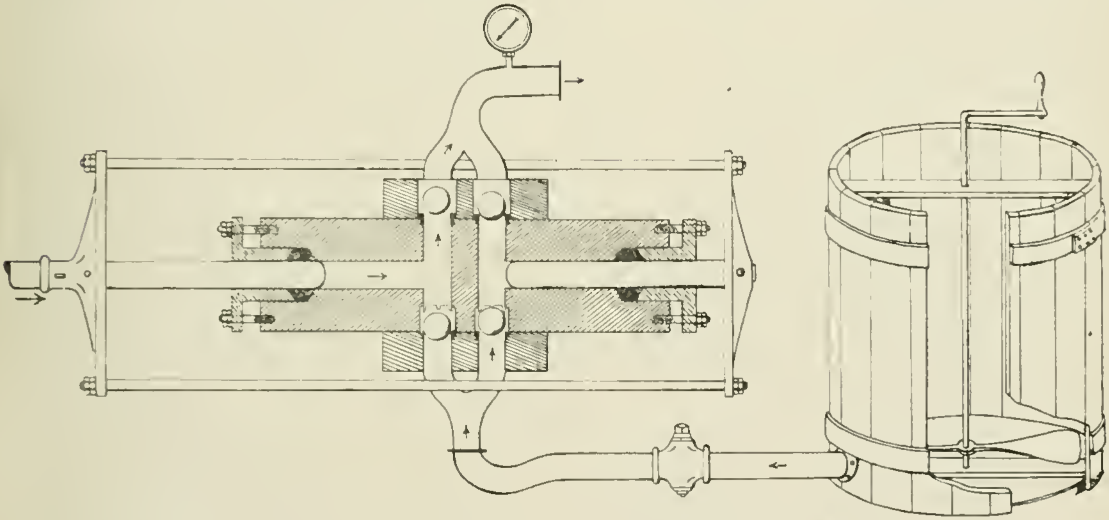


Fig. I.—Diagrammatic Sketch of Water End of Cementation Pump and Mixing Tub.

Application of the Cementation Process.—As mentioned before, my experience of the process is somewhat limited, but is sufficient to convince me that there is scope for its extensive application on these fields, and that it will certainly prove of great economic value. As an instance, the total cost of pumping on the Rand amounts to over half a million pounds annually, so that if a fair proportion of the many "drops" of water were economically sealed back, an "ocean" of expense would be saved, while the important application of the process in connection with shaft sinking through water-bearing strata, such as the dolomites of the Far East Rand, should in itself greatly reduce expenditure in that area.

In the following cases cementation has been successfully applied:—

1. In greatly minimizing water difficulties in shaft sinking or tunnelling through water-bearing strata, faults and dikes.
2. In sealing and rendering water-tight the concrete tubbing or lining often used in circular shafts.
3. In sealing open fissures through which water is flowing.
4. In damming back water leaking through broken ground, in the vicinity of faults and dikes.
5. In rendering underground dams water-tight.
6. In rectifying defective boreholes.
7. In rendering impervious the foundations of surface dams or making solid the rock and concrete foundations of engines, etc.

1. *Shaft Sinking.*—The process as applied to shaft sinking consists of a treatment of the strata, through which the shaft is to be sunk, with cement grout, which is injected into the fissures and cracks of the rock mass, thus sealing them and rendering the ground practically free of water. The method of carrying out the work is as follows:—A system of drill holes is put down on the periphery of the shaft, and through these holes a thin cement mixture is introduced, which finds its way into the cracks and crevices, rendering them impervious to

water. There are two methods of carrying this out. In the first the holes are put outside the perimeter of the shaft (this method being associated with a Mr. Portier), and it is claimed that it has the distinct advantage of permitting the sinking of the shaft simultaneously with the injection of the cement. This is a very strong point, and but for the undermentioned disadvantages, this scheme would have much to commend it over the François method, in that it practically overcomes the interruption and delay to the sinking of the shaft while conducting the process. The disadvantages of the Portier system, however, are so important as to make one reluctant to adopt it in preference to that of the François system. Of the disadvantages referred to, the chief are:—

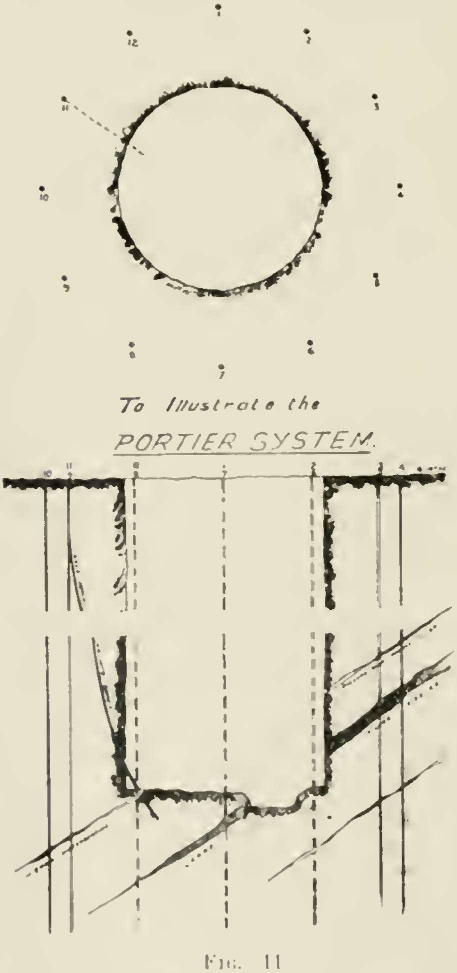


Fig. 11

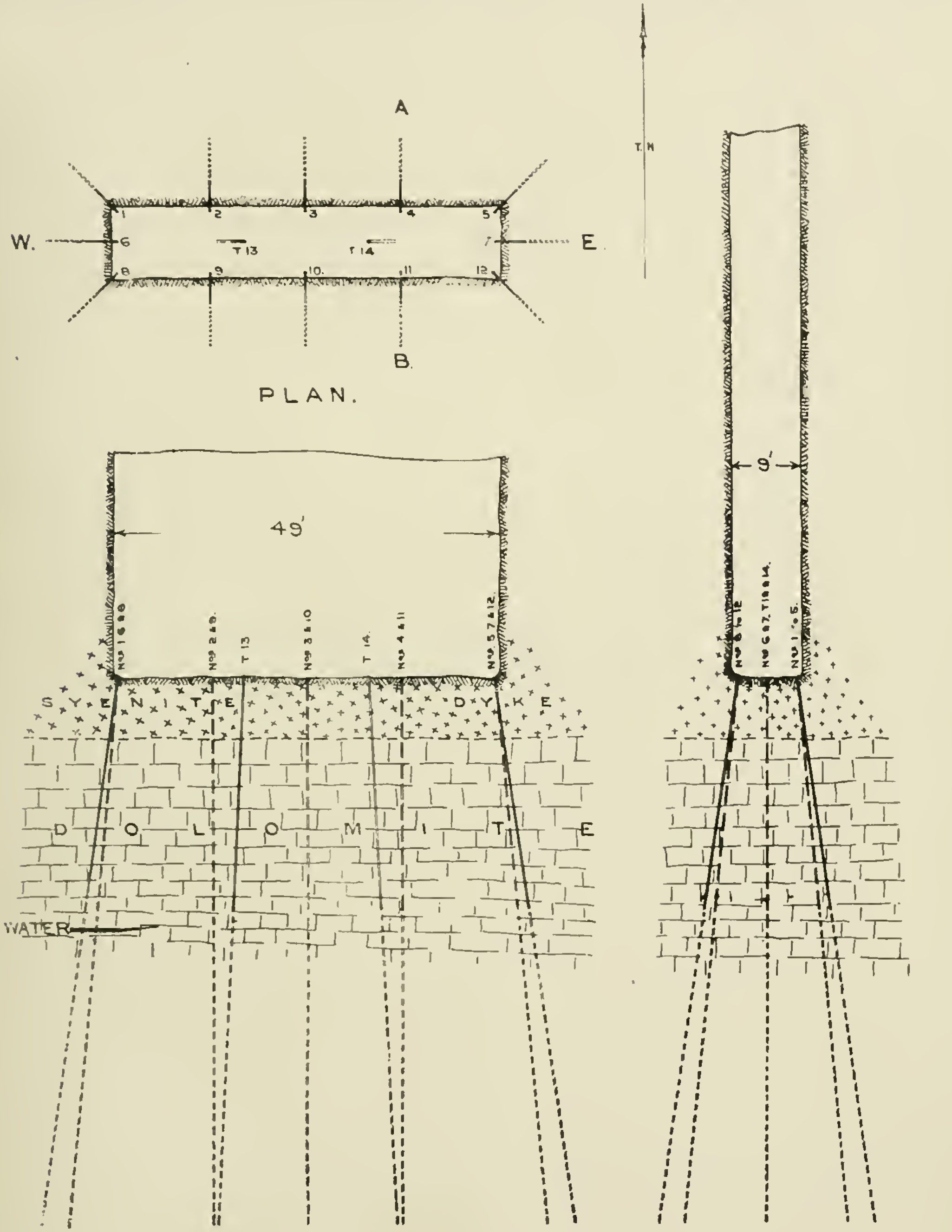
(a) The possible deflection of the boreholes into the shaft, rendering them useless for the subsequent injection of cement.

(b) The danger to sinkers, when applying great pressure in the boreholes, owing to the possibility of rupturing the sides of the shaft.

(c) The boreholes may intercept several fissures, but the mouth of the hole being above the water level, it is not possible to tell which fissure is the chief water carrier, so that when injection takes place the tendency will be for the cement to take the course of least resistance into the larger fissures, while the smaller ones, though probably of considerable importance, are only sealed in the vicinity of the hole itself.

In the François system the boreholes through which the cement is introduced are put down, within the limits of the shaft, arranged on the perimeter, at various distances apart, depending on the size of shaft and thickness of rock strata to be treated. The detailed method of procedure is indicated by the following description of the work being done at the Daggafontein and Brakpan Mines:

Daggafontein No. 2 Shaft is a seven-compartment rectangular shaft, 49 ft. long by 9 ft. wide, and was sunk from the surface to 175 ft. in dwyka conglomerate containing numerous cavities and fissures; giving a fair amount of water, but not of such quantity as to seriously hinder sinking. At a depth of 351 ft. the well known syenite dike of the far East Rand was encountered, and the shaft sunk in it to its present depth of 500 ft. At this stage the water dealt with amounted to 21,000 gallons per hour, and the management decided to put down a pilot borehole to ascertain the nature of the strata ahead. This hole intercepted the dolomite series at a depth of 12 ft. below the shaft bottom, and at a depth of 165 ft. a considerable amount of water was encountered. In view of the probability of large quantities of water being met with in the dolomites, shaft sinking was stopped, and the adoption of the François Cementation Process decided upon. From the data available the thickness of the dolomite formation was estimated at 200 ft., the direction of the boreholes being set out accordingly so as to permit of a single stage treatment for the full width of the strata. Unfortunately, the thickness of the dolomites proved to be considerably more than anticipated, being a total of 315 feet, which distance was considered too much for treatment in one stage. A distinct open parting exists at the contact of the syenite dike and underlying dolomite. This was clearly demonstrated, for when drilling through the dolomite contact the feed water was forced out of holes previously drilled. At a depth of 35 ft. the first feeder was met with con-



PLAN.

SECTION ON W. E.

SECTION ON A.B.

Fig. 111.—Daggafontein Mines, No. 2 Vertical Shaft. Plan and Sections showing arrangement of Boreholes for Cementation Process. Holes 1-12, 8° out; Holes 13 and 14, 2½° out.

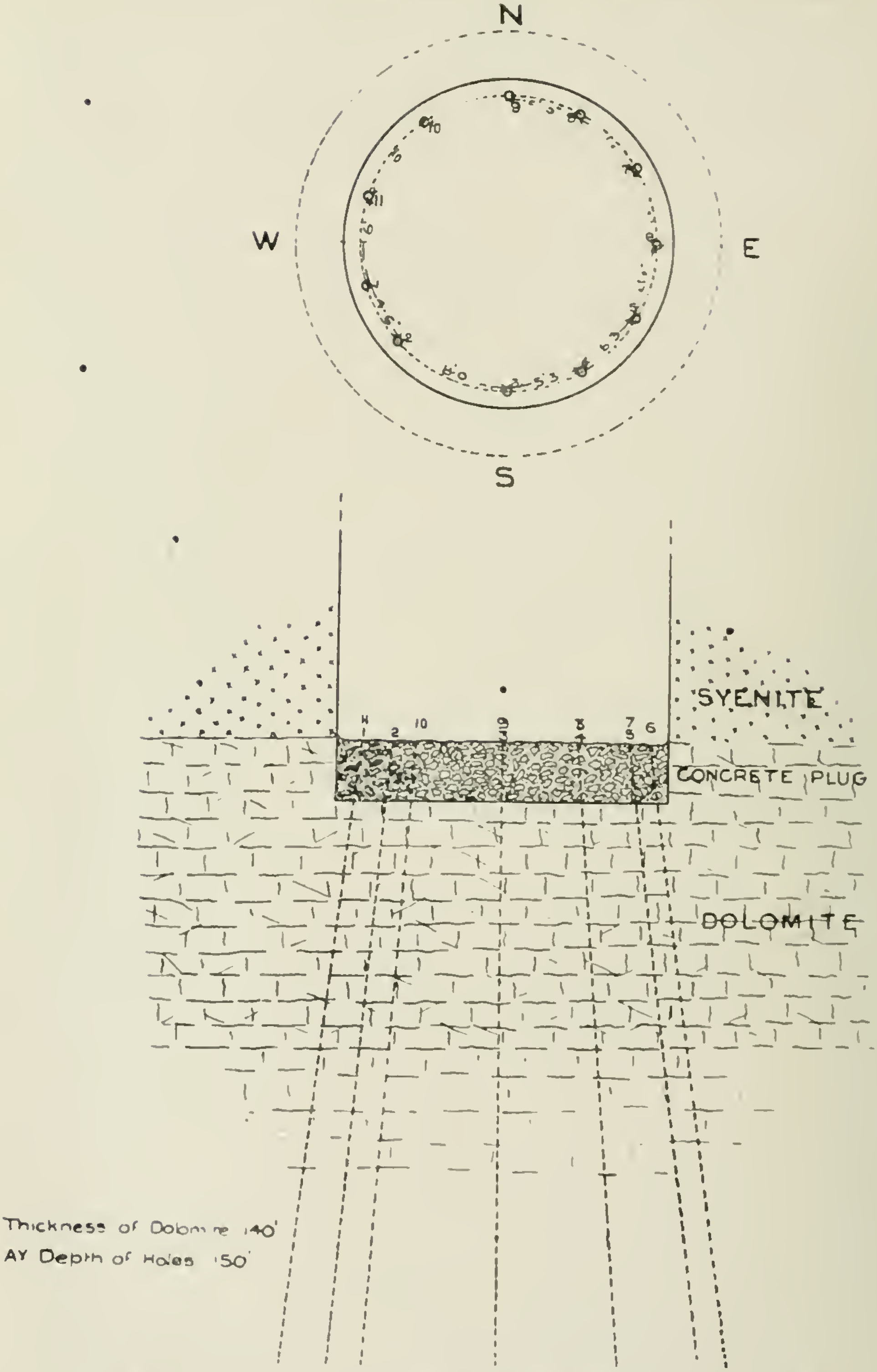


Fig. IV.—Treatment Plan, No. 3 Circular Shaft, Brakpan Mines. All Holes Dip 8° out.

taining sufficient water to cause a flow of 250 gallons per hour out of a 1½ in. drill hole. A second and larger fissure was struck at a depth of about 130 ft., and as each hole intercepted water, cement grout was injected, the progress of the injection being observed by the rise in pressure indicated on a pressure gauge. When a pressure of 2,000 lb. per sq. in. was reached, pumping was stopped, and the cement allowed to set. In all 55 tons of cement were used, and as the depths of the holes are all about 180 ft., sinking can now be continued for that depth; it is confidently expected that when the fissures are passed through, very little water trouble will be experienced.

Brakpan No. 3 Shaft is a 20 ft. diameter circular shaft, and from the surface to 162 ft. is sunk in dwyka conglomerate. At a depth of 170 feet the syenite dike was met and sinking was continued through this dike and for 6 ft. into the underlying dolomites. At this point a sudden inrush of water occurred which flooded the shaft to a depth of 80 ft. in a very short while, the suddenness of the inrush causing the death of a native. The method to be applied at this shaft will be similar to that employed at Daggafontein, except that in this case the shaft had in the first instance to be dewatered by pumping and baling, and when sufficiently dry a concrete plug about 5 ft. thick was placed on the shaft bottom, with a release pipe to take off the water while laying the concrete matt. After allowing the concrete time to set, holes will be put down as shown in the accompanying sketch, and the treatment carried out in a manner similar to that already described. In this instance, however, the dolomite beds being only 110 ft. thick one stage treatment will be sufficient. It should be mentioned here that even had this inrush of water occurred at a much greater depth with considerable pressure, and of such quantity that the shaft could not be conveniently dewatered, the concrete plug could be put at the shaft bottom with no great difficulty, advantage being taken of the water rising in the shaft to its natural head.

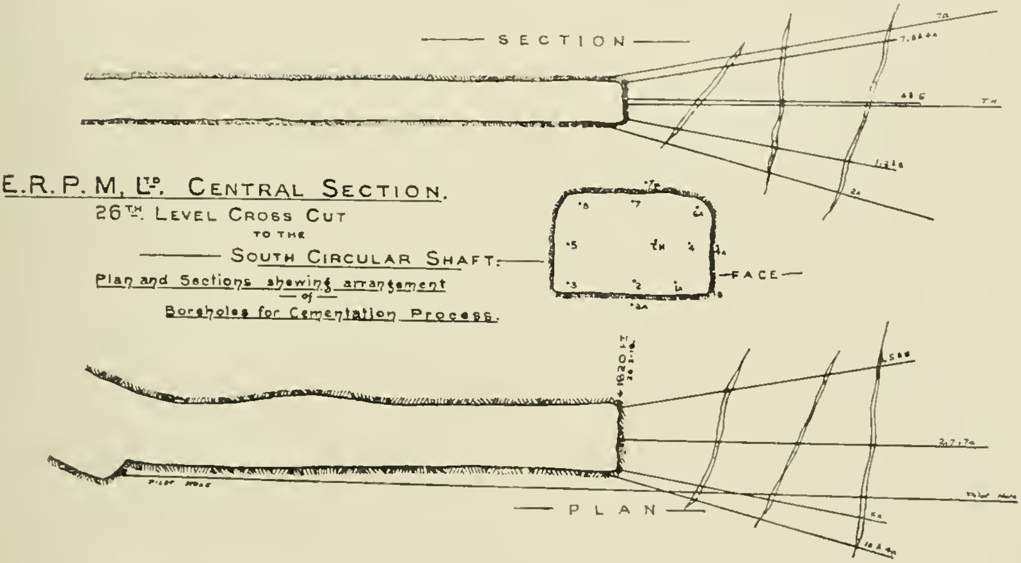


Fig. V.—Water Pressure here 1,000 lb. per sq. in.

When required to drive a tunnel through a water zone the method adopted is very similar to that just described for shafts, and I am pleased to say that the results obtained at the East Rand Proprietary Mines in this connection have been very satisfactory. Two different examples of this work were conducted at the E.R.P.M., the one being a case where the water was located by advance boring in the 26th crosscut south, and the other where the water was unexpectedly struck in the 30 Level West Drive. In this instance a 12 ft. brick dam was built with certain pipes arranged through it to allow of the water escaping while building the dam, and to permit of

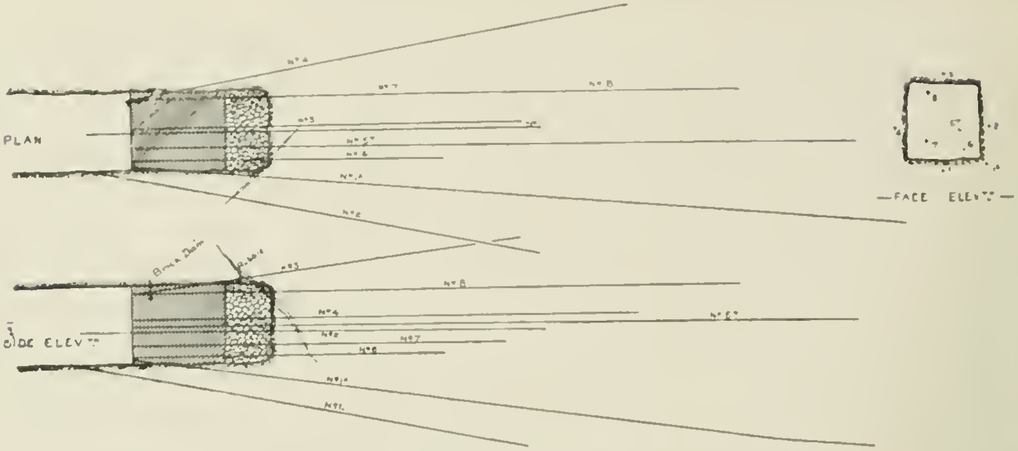


FIG. VI.—30 W. Drive, East Rand Proprietary Mines. Showing Brick Dam with Rubble Filling behind and arrangement of Holes for Cementation.

cementation being subsequently carried out. It should be noted that at the West Shaft 1,500 ft. away from this point, a borehole had struck water of the same pressure, suggesting the same source of water as in this drive, and as proof of this when injecting at this dam some cement came out of the borehole in the West Shaft, clearly showing how well the cement at times will travel.

Before passing on to application (2) I would like to make mention of a difficulty which arose during cementation work at the Hatfield Main Colliery, Yorkshire, England, where it was practically impossible to force the cement into the fissures in the old red sandstone formation. In attempting an injection of these fissures it was found that the cement would not travel any distance, but would set immediately in the vicinity of the boreholes. At first the operators were completely baffled by this difficulty, and it was only when Mr. Francois hit upon the following idea that complete success was obtained. It was argued that the cause of the trouble was due to the fissures being all more or less filled with sand and dirt, the product of the sandstone, and that when forcing the cement into these fissures the sand would act as a filter bed and the cement would immediately pack into a mass; and consequently not travel into the fissure. To overcome this, solutions of silicate of soda and sulphate of alumina were separately injected into the fissures. These chemicals reacted on each other and form in the fissures a gelatinous or colloidal substance, which being forced through, carried away the sand, leaving the fissures open and clear to receive the cement. It also seems to line the walls of the fissure with a thin smooth layer of chemicals, and thus acts in the manner of a lubricant which nullifies the frictional resistance of the walls of the fissure.

(2) *Sealing Ferro-concrete Shaft Lining.*—In shaft sinking, particularly in the case of circular shafts, a lining of ferro-concrete or bricks is generally adopted, and in this connection it frequently becomes desirable to dam back water behind the lining. As this water may be under a considerable pressure the problem is no easy one, unless a process such as the Francois method is adopted. In this instance a number of weep pipes are built in with the lining, which allows the escape of the water while the lining is being constructed, thus relieving the "green wall" of the water pressure. After allowing the lining sufficient time to set, the weep pipes are in turn connected to the cementation pump, and cement grout is injected behind the lining and into the fissures, in this way sealing them up. Should the lining of the shaft not be of sufficient thickness to permit of a large pressure being applied, the method adopted is somewhat modified in that before direct injection takes place one or more release boreholes are drilled through the walls of the shaft well back to intercept the fissure at a considerable distance inside the rock. These holes allow the water to escape and relieved the side of the shaft of the pressure necessary for cementation. A thick cement mixture

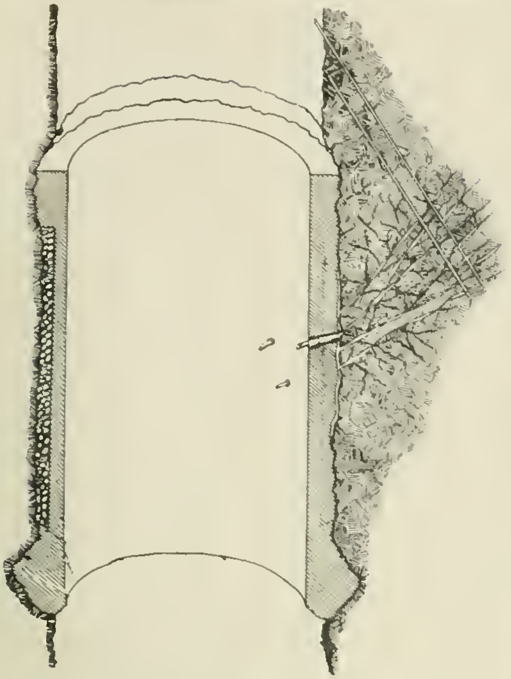


FIG. VII.—Sectional Sketch of Concrete Tubbing in a Circular Shaft, showing Fissures, Weep Pipes, Release Holes and general arrangement for Cementation Treatment.

is then introduced through the weep pipes, which seals the fissure in the immediate vicinity of the shaft, and when set the final injection takes place through the release holes mentioned. By systematically dealing with all water in shafts in this manner it is quite possible to get a perfectly dry shaft.

(3) *Sealing of Open Fissures.*—Generally speaking, the method adopted in dealing with open fissures through which any considerable quantity of water is flowing is to drill two or more release holes at some distane back from the mouth of the fissure for the purpose of allowing the escape of the water during the time of sealing the opening of the crevice. It is readily understood that unless some system like this is used the force of the water would wash out the cement grout as fast as it is injected, if, however, the water can find an easier escape through these release holes it will take that course, and thus permit of the following treatment:—

The flow of water from the mouth of the fissure is first of all restricted by carefully wedging it. Thick cement, with an addition of sawdust when necessary, is then injected through one of the drill holes, and settlement begins on the support offered by

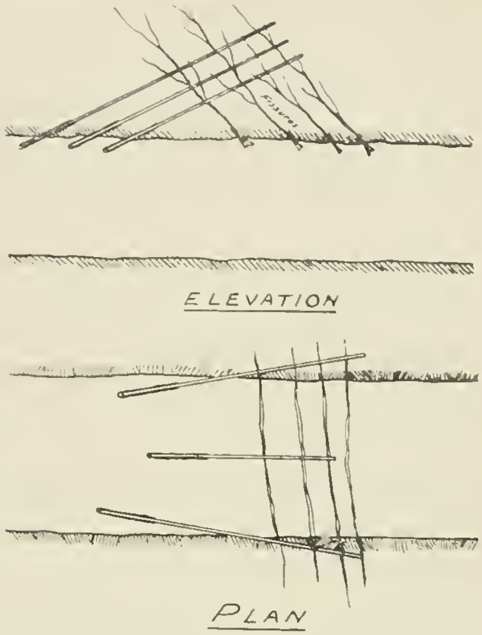


FIG. VIII.—East Rand Proprietary Mines, 26th Cross Cut. Cementation of Open Fissures, showing Wooden Wedges, also Release and Injection Boreholes.

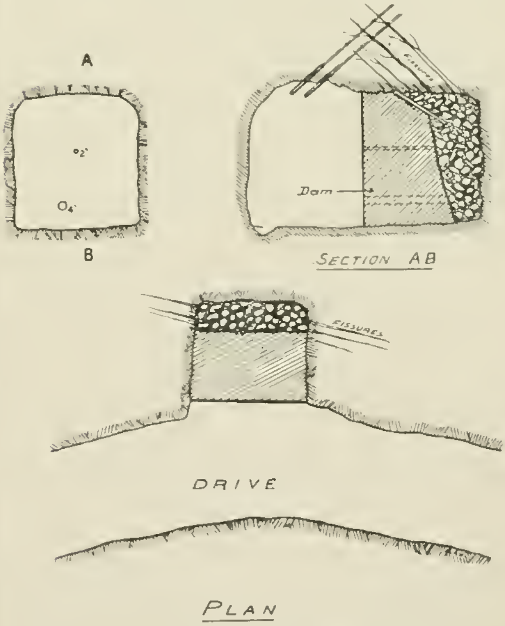


FIG. IX. East Rand Proprietary Mines, Ltd., 28th W. Drive. Fissure, showing Concrete Dam and Rubble Filling: Water Pressure 400 lb. per sq. in.

the wooden wedges driven into the open end of the fissure. When this cement has set in the area between the release holes and the fissure opening, the final injection takes place directly through the release holes.

As an example of this class of work it might be mentioned that in the 28 West Drive, Angelo Deep, a certain fissure allowed an escape of about 3,000 gallons of water per hour; this was treated in the manner described, and within eight hours the water was effectively sealed off. A modification of this class of work has been successfully carried out at the Geduld Proprietary Mines. In this case, however, the fissures were of a very wide nature carrying a large quantity of water, and it was deemed advisable as a preliminary to build a cylindrical concrete dam at the point where these fissures intercepted the drive. I will not give a description of the method of building this dam, as in itself it would form the subject of quite an interesting paper. Suffice it to say that the dam on completion, as expected, was found to leak badly, and at this stage the cementation pump was brought into use, and the dam rendered water-tight. Practically speaking, this operation is the same as that described above in connection with shaft lining.

(4) *Damming back water in the vicinity of broken ground.* The process adopted for sealing back water leaking through the cracks and crevices of broken ground is similar to that adopted for sealing open fissures, though at times it calls for special care, as the weak nature of the rock tends to burst it out when subjected to pressure while injecting.

(5) *Rendering underground dams water-tight.* It has no doubt been the experience of many present here that however carefully an underground dam is constructed a great deal of leakage takes place, more especially when the water is under considerable pressure. In this connection cementation can be particularly successfully used for making the dam water-tight by injecting cement through holes suitably drilled into the construction. As a good illustration of this work, I would mention the large central dam built in the 26 Crosscut at the E.R.P.M. This dam is 30 ft. thick and has an opening sufficient to permit of a one-ton car travelling through. It was designed to withstand a water pressure of 1,000 lb. per sq. in., but when tested at 200 lb. was found to leak somewhat badly

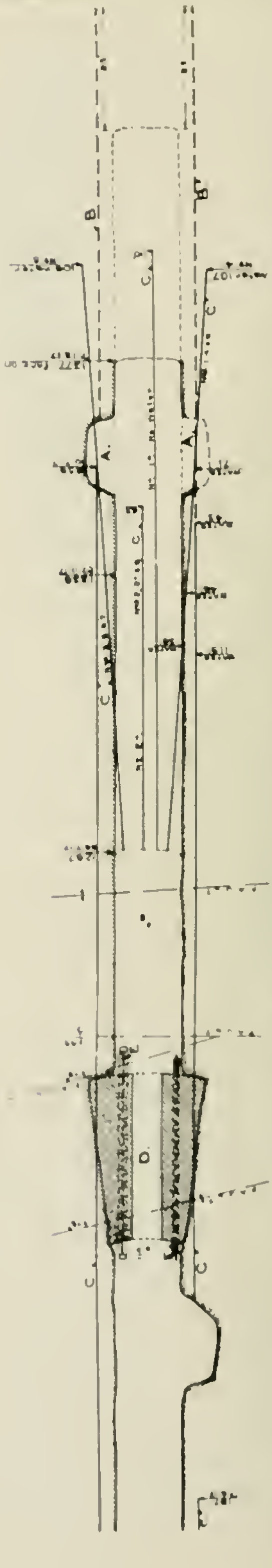


Fig. 8. Plan of 26th Level Cross Cut to the South Circular Shaft, showing scheme of keeping two Pilot Boreholes in advance of Cross Cut Face during its course through the probable Water Zone. (A) Recess for Diamond Drill. (B) Boreholes to be at least 20 ft. in advance of Face of Cross Cut. (D) Brickwork Dam to withstand Pressure of 1,000 lb. to sq. in., built as a precautionary measure.

Cementation was then resorted to and the dam most effectively sealed.

(6) *Rectifying defective boreholes.*—Sometimes boreholes for the purpose of obtaining domestic water are required to pass through one or more rock strata containing inferior or corrosive water. In such cases the usual method is to line these boreholes with metal tubes, but these tubes frequently become corroded at the point of contact with the bad water, with the result that they become useless and the good water is polluted. In this case the upper feeders of bad water can be successfully closed off by means of cementation.

(7) *Rendering impervious, foundations of dam walls, etc.*—It frequently occurs that at the site of a dam the rock foundations are of such a nature as to be unsuitable for the the purpose of withstanding the pressure of the water behind the dam. This in the usual way is overcome by deep excavations, which consequently greatly increase the cost of the dam. At the present moment it is intended to treat by means of cementation the pervious rock foundation at a dam site in the Mazoe Valley, Rhodesia, and there is little doubt but that the operation will be quite successful and so greatly reduce the expenditure on this dam. Briefly, the rock foundation is treated with cement introduced through a system of drill holes. Foundations of engines and machinery generally when ruptured can be very effectively strengthened and solidified by cementation work.

I should like to acknowledge here a paper read by Mr. Thomas Blandford before the Institute of Mining Engineers, England, from which I have gathered much information, and from which I take the following examples of cementation successfully applied in Great Britain:—

Two rectangular shafts were sunk at Kingshill Colliery, Lanarkshire, through coal measures, cementation being used at a depth of 300 ft.

Two shafts were sunk at the Plenmeller Collieries, Northumberland, and were completed by cementation from a depth of 180 ft. to 700 ft.

At Blackhill Colliery, Durham, a larger feeder of water was successfully dealt with by means of a concrete plug fixed in the shaft under water. In this case the initial volume of water amounted to 380,000 gallons per hour. All the large fissures were found filled with well set cement, and it is claimed that if greater care had been taken the feeders could have been reduced to quite negligible quantities, but on account of the large pumping plant available this was not considered necessary.

At Fishburn Colliery, Durham, two shafts were sunk after first being treated by cementation.

In Yorkshire, as previously mentioned, cementation was used at Hatfield Main Colliery.

Cementation was also effectively applied when sinking through water-bearing limestone at Rossington Colliery.

In Warwickshire cementation was used at Coventry Colliery for shaft sinking.

In Staffordshire one of the shafts at Holditch Colliery was sunk in red sandstone with the aid of cementation.

In Kent the water in the chalk measures has been dealt with by cementation.

In Wales, at the Cwm sinking of the great Western Colliery Company, cementation was adopted after previous sinking with pumps. The results were highly satisfactory, and water at a pressure of 350 lb. per sq. in. was closed off.

As far as I know, cementation is also being carried out at the following collieries, though this list is far from complete:—Coventry Colliery, Llay Colliery, Ledstone Colliery, Copper Pit Colliery, Crumlin Valley, Simonstone, Wolstanton Sinking, Pleasley Colliery, Blaenavon Colliery.

A series of analyses of different cements and the various deposits obtained during cementation operations has been kindly carried out by Mr. Toombs, and the results are appended.

My thanks are due to Dr. Voskule and Mr. Toombs for the help given me in conducting the experiments in connection with the setting of cement, and to Dr. Voskule for preparing the very excellent lantern slides shown here this evening.

In conclusion, I trust that members will freely criticize this paper so that as far as possible a full record of all knowledge of this subject may be made available.

The Chairman: This Society has always been extremely fortunate in being the mouth-piece of the most original work that has been done on the Rand in chemistry, metallurgy and mining, and, if you think I am overstating the subject, we have this evening another example of how we are able to present something new to the Rand.

Mr. Krynauw is very modest in saying that he has only recently become acquainted

RESULT OF ANALYSIS OF NINE SAMPLES TAKEN IN CONNECTION WITH THE "CEMENTATION" PROCESS

Preparation of Sample for Analysis.—Samples were dried on water bath, then powdered and dried in oven at 110° C. for three hours to drive off all moisture except "combined water." Portion was then ground in agate mortar and bottled for analysis.

DESCRIPTION AND ANALYSIS

	Lumps almost set. 1	Cement as used taken at working place. 2	[illegible] 3	Similar to (3) but more moist. 4	Watery Slime. 5	Similar to (5). 6	Pretoria Portland Cement. 7	Set Cement Borehole Core. 8	Bulawayo Portland Cement 9
Loss on ignition	4.76	1.82	6.98	7.90	10.44	11.78	1.01	13.60	2.44
Insoluble SiO_2	2.00	0.90	6.32	3.18	12.42	12.41	0.90	0.80	0.58
Soluble SiO_2	25.51	25.02	23.42	24.40	18.94	19.47	24.98	22.88	21.36
CaO	58.60	62.40	53.10	55.60	48.10	42.30	63.10	52.50	62.42
$Fe_2O_3 + Al_2O_3$	7.60	8.04	7.48	7.44	7.36	7.50	8.18	8.34	11.22
MgO	0.65	0.63	0.83	0.83	0.67	1.49	0.50	0.68	1.42
SO_3	0.65	1.25	1.78	0.78	1.61	2.09	1.20	1.10	0.37
TOTALS	99.80	100.06	99.91	100.13	99.24	99.74	99.90	99.90	99.81
CO_2	1.20	Traces	2.40	2.70	3.20	4.80	Traces	2.40	Trace.
CO_2 as $CaCO_3$	2.72	—	5.45	6.13	7.26	10.90	—	5.45	—

I am of opinion that there is a tendency for the calcium silicate of the cement to react with the carbon dioxide of the water in the fissures, thereby throwing silica out of solution, and forming insoluble calcium carbonate. The introduction of a very weak solution of water glass or caustic soda would overcome this tendency.

I am also of the opinion that Samples 2, 7 and 9 are not sufficiently "hard burnt" cements, as all the lime does not seem to be combined with the silica—if this were so there would be a tendency for the uncombined lime to go into solution, thereby upsetting the constitution of the cement, the "cementation" process lending itself to this owing to the large dilution. A method for soluble CaO gave the following results:

	1	2	3	4	5	6	7	8	9
Soluble CaO	5.4	8.8	3.8	8.4	3.5	3.5	9.7	—	10.5

The CaO content by analysis taken with the comparative soluble CaO figures more or less bear out the contention stated above.

The whole nature of the "cementation" process demands that a cement should be used in which the constituents should be insoluble, or as nearly insoluble as possible, therefore a highly hard burned cement in which all the lime is combined with the silica is preferable for the process.

East Rand Proprietary Mines Laboratory,
6th April, 1918.

(Signed) CHRIS. TOOMBS,
Chief Assayer.

with the details of this process, but I think Mr. Francois can congratulate himself on having such a very apt disciple.

It is hardly necessary for me to emphasize that the paper, is one of extreme interest; it covers such a wide range that it is very difficult to see to-day the limits of its future application here on the Rand in both underground and surface work. I think we are only just beginning to realise what can be done, and I am quite certain that, to many of you who are comparative strangers to it, it will strike you as a subject of extraordinary interest, which will stimulate your ingenuity in applying it in all sorts of fashions, other than to the very difficult problems that we frequently have to face underground.

In connection with this subject, I happened to pick up a paper—the Proceedings of the Australian Institute of Mining Engineers, 1917, wherein is given an example as to how cracks and fissures were dealt with in a shaft at the Edna May Deep Levels, Western Australia. Here it explains that the mine is quite a small one and was not in command of the unlimited capital required for pumping the very large quantities of water that were met in shaft sinking. This mine is apparently a relatively new concern, and its future awakened a good deal of public attention; so much so that the interested public was looking forward to the announcement of the manner in which it was proposed to combat the water in the mine. When it was stated that it was proposed to block up these cracks with cement, an outcry of derision took place. Several newspapers of fairly wide circulation there, violently attacked the management and declared that the proposal was utterly absurd and ridiculous, and even fraudulent, and argued that it was simply an attempt to bolster up the shares.

In this case the point of interest was that the pump used was a Cornish pump, adapted in a very ingenious way to produce a pressure of 2,000 lb. to the square inch. It is difficult to describe how the arrangement was carried out, but it appears to have been entirely successful in overcoming the problem, which is very similar to those we meet here. The strange feature, however, is that the writer of the paper states that the idea of using cement in this way is quite original, he has apparently never heard of the François process. This is a paper written and published in the Proceedings of the Australian Institute of Mining Engineers in 1917. He incidentally also mentions the use of saturated solutions, for example, of calcium chloride and sodium silicate, with the idea of forming a calcium silicate precipitate, which can be consolidated under high pressure. He also speaks of sulphate of alumina, and silicate of soda, and similar reagents, exactly the same as were used in the Hadfield Main Sinking, passing through the porous red sandstones at home.

I am sure we shall get a very free and open discussion on this subject, and it is one that will continue for a considerable time, as opportunities present themselves for applying the process and practice in various places. I would move a hearty vote of thanks to the author for this interesting contribution to our transactions.

Sir Harry Ross Skinner *(Visitor)*: I am very glad to second the Chairman's vote of thanks to Mr. Krynauw for his most interesting paper on the François cementation process. I am quite sure, in my own mind, that there will be great development of this process on these fields, and also throughout all South Africa. It is only in its infancy and will repay very minute study. It is one of those processes which are often come across, that on the surface seem exceedingly simple; but when the man who does not understand the why and the wherefore commences to apply them, he finds he cannot attain any success. M. François was out here some nine months ago. He came to deal with the water problems of the East Rand Proprietary Mines and Mr. Krynauw was attached to him. When he left after being here for a short time, Mr. Krynauw carried on his work most successfully, in fact, that work is now extending so far and in so many directions that it came to the point of Mr. Krynauw going over to the cementation process or carrying on as a mine manager. Well, he has decided to carry on his work as mine manager. I am rather disappointed at that, because we were all hoping he would go on with cementation. However, Mr. Blandford is now on the water. Mr. Krynauw referred to Mr. Blandford, who is M. François' partner, and I am sure when he arrives he will find that Mr. Krynauw, and associated with him Dr. Voskule, have done all possible to preach the gospel of cementation.

We have some very interesting work coming on in this direction, and I am sure the engineers on these fields will watch it with great interest; and whatever there is to be seen and known about it, these gentlemen will be more than glad to demonstrate to those who are interested.

Prof. G. H. Stanley *(Past-President)*: There is one aspect of this matter to which I think attention might be called. The mining people are dealing with it because they do not want the water, but incidentally they are conserving in the strata water supplies for those who do.

We understand that a few months ago there was considerable perturbation in Pretoria over the prospect of their water supply diminishing. They draw their supply from springs, I believe, coming from the dolomite, and, of course, a considerable portion of the water used on the Rand comes from the same source. If the mines on the East Rand were to deal with the water difficulty in the same manner as elsewhere—that is, by putting in tremendous pumping capacity, it is conceivable that the underground water supplies might be seriously diminished, but the wide adoption of cementation will certainly tend to conserve the water supply in the strata.

Mr. H. A. White *(Vice-President)*: There is another aspect of this question which has struck me, and that is, in this paper no reference whatsoever is made to the cost of the process; so I suppose that part of it must be quite satisfactory to those using it. However, I notice that pure cement only is mentioned, and I suppose there may be some reason which would render it absolutely impossible to mix the usual proportion of sand, which, in this case, would have to be exceedingly fine, but which could readily be obtained either from our sand residues, or by cheap treatment of our slime dumps. It is a bit puzzling to me to observe that no attempt has been made to reduce expense by substituting for some of this expensive cement a much cheaper material, because the great bulk of the work seems to be mere space filling—filling up spaces in addition to securing them from water filtering through.

ELECTRIC FURNACE MANUFACTURE OF SHOES AND DIES ON THE WITWATERSRAND.

By Geo. H. Stanley, A.R.S.M., F.I.C., M.I.M.M. (Past-President)

(Printed in Journal, September, 1917.)

REPLY TO DISCUSSION.

Prof. G. H. Stanley: Mr. Woodburn's conception of the function of this type of furnace as a melting and not smelting one is, of course, correct. The heat is generated in the metal itself and it is difficult to keep a slag fluid, so that its use is limited to melting metals, or a mixture of metals, which require a minimum amount of refining.

It is for this reason that in selecting the raw materials in this case the choice is practically confined to scrap metal of approximately the same composition as is desired in the finished product, and additions are merely made to correct losses in melting. In Sweden and elsewhere, however, it is employed for making steel from pure pig, *i.e.*, low in phosphorus and sulphur, and scrap.

Silicon is lost by oxidation by both air and scale, and this is corrected by addition of low phosphorus pig iron carrying about 3% silicon; the amount used being about 56 lb. per cast (about one ton).

Manganese is subject to diminution from the same cause, and is made up by addition of from 30 lb. to 50 lb. of manganese steel mortar box liners. The amounts are decided by reference to analyses made from time to time which will be referred to later on.

As long as charcoal was used in the furnace the carbon was apt to be much too high, being especially difficult to keep within limits on the night shift. So, in spite of the strong predilection for it manifested by the furnace hands, its use has been abandoned. It had, as a matter of fact, become much less necessary with the more rapid working and quicker melting resulting as experience was gained, but in its absence more labour and more constant attention is needed to prevent formation of the "crust" referred to. In addition, the slag appears to be more corrosive, and this contributes doubtless to the relatively short life of liners.

The smelting furnace now under construction at Vereeniging is a blast furnace, small, of course, but of ordinary type; electric smelting is not contemplated. Mr. Woodburn is possibly confusing this with the electric steel furnaces, also under order, for the production of high grade steels; these, I understand, will be arc furnaces.

Mr. W. H. Dane's contribution gives valuable information.

Certainly, as the chairman remarked, he does not flatter the local product, but it is only by specific criticism of this kind that the producing concern can learn exactly in what manner the product is defective, and in what directions improvement is required.

The earlier product was very subject to blowholes, castings being often very unsound. This was to a large extent remedied by increasing the amounts of silicon and aluminium added, the high carbon content also making for improvement in this direction. It was also of lower carbon content (before charcoal was used), being made slowly and with more oxidation taking place, and that, no doubt, explains both the lower percentage of breakage owing to the metal being tougher, and shorter life, owing to its being softer. It must be admitted, however, that the product was very irregular, successive analyses showing up to nearly 100 variation in carbon content. Now, with regular and systematic working it can with confidence be stated to have much improved. It has not, however, been possible to instal any appliances for forging, and this is the more to be regretted in view of the great improvement secured in this manner by Mr. Jane. Evidently the composition of that lot was about correct, they could scarcely have been successfully forged had the carbon content been excessive. This high carbon content, sometimes 1·3 or 1·4, and in one instance 1·47, was the chief fault throughout the year 1917, and led to high percentage of breakage of shanks in most mills, and though the steps taken from the commencement of 1918 have been successful in remedying this, there was at the end of the year a large accumulation of stock, which was issued during the early months of this year, and from the behaviour of which our reputation still suffers.

Mr. J. M. Dixon's contribution also is most valuable, and as his experience has been very similar to Mr. Jane's, the same remarks apply.

It is very interesting, and carries some consolation also, to learn of the poor performance of imported cast steel shoes under the same conditions, but evidently the conditions obtaining in the Robinson Deep mill are very severe on the shoes and dies. This is reflected in the 3½ of breakages among imported forged steel shoes and also in the figures relating to the comparative test carried out in 1913. These figures show truly surprising variations in quality, for which, in the absence of analyses, it is difficult to assign a reason. Even 3½ is higher than is common, I believe, but there seems to be a consensus of opinion among mill men that current supplies of shoes and dies from oversea are not by any means up to pre-war standard. On one mill, indeed, I was informed of a consignment of which 31 of the shanks had broken.

It is gratifying to note the good behaviour of the local dies, and presumably this is due to their hardness consequent on high carbon content. In this direction the requirement for shoes and dies seems to be somewhat different, for if the carbon is reduced to make the shanks satisfactorily tough there is risk of the metal becoming too soft and abrading more rapidly. However, it seems that about 0·9 of carbon would satisfy both requirements and, of course, it is endeavoured to keep it at that or thereabouts, with what success will be seen from the analyses dealt with subsequently.

Mr. Inglis also presents a useful contribution, giving the experience at the Nourse Mines, which is quite similar to that of other users.

I think the contributory effect of the abnormal conditions noted would certainly be very considerable, as even the best of shoes would be most adversely affected, nevertheless the high carbon was undoubtedly largely to blame for the high percentage of breakage, as already explained.

The rapid wear during the early life of the shoes, also noted elsewhere, is doubtless due to the cause suggested, and this has been to a considerable extent rectified by making the casting headers more substantial and not breaking them off till quite solid. There is still a variable amount of blowholes present, however, which could only be closed up by forging, which is unfortunately impossible under present conditions. The crumbling mentioned by Mr. Inglis as occurring when forging was attempted indicates how very high the carbon content must have been.

My thanks are also due to Mr. Pepler, whose contribution deals with the relative wear from a different standpoint, and whose experience of the local product has evidently been much more favourable than that of the other contributors to the discussion.

I am glad to note that he finds considerable improvement recently, and as a whole no greater amount of breakage than in the imported article. He evidently takes very great care in the installation of his shoes and dies, and his carefulness is reflected in the critical attention he pays to the shape also, returning those he considers unfit for use.

It must be conceded that a good deal of last year's product was very bad from the shape point of view, resulting in shanks being of irregular cross section instead of circular, and in consequence giving rise to "rocking" and alternate stressing in use which contributed greatly to rapid fracture. In addition the chill moulds tend to warp after being in use some time. These defects are obviously corrected by paying greater attention to proper fitting of the two halves of the moulds, and by discarding distorted moulds. Considerable irregularity of the base of the dies can be dealt with by setting them on battery chips, as at the Crown Mines, nevertheless, I hope he will be able to note improvement in this direction in the future.

Mr. Weston throws out a good suggestion, which has been noted for trial, though it is hoped the necessity will be obviated. However, our bad product is still much better than cast iron, and having regard to the relative areas of cross section of the proposed core and the whole shank, the possible improvement to be effected would be much less in our case.

He calls attention also to another factor, which does considerably influence the life of shoes, *i.e.*, care or carelessness in setting them, and this apparently has a great deal to do with the extremely variable results obtained on different mines.

The Committee of Control much appreciates the care and attention which has been given to ascertaining and recording the behaviour of the electric furnace product, and is confident that the present production will show much improvement in quality. It is generally months after the shoe and die is made that reports of its behaviour are to hand, but encouraging reports are already being received.

The Robinson G.M., on whose property the plant is situated, appeared to furnish a convenient "testing shop" for the product; and owing to the condition of the battery after a long and honourable career and approaching end of the life of the mine, the test was a very severe one. The earlier results were, however, so disastrous that it is a tribute to the good nature and willingness to help of Mr. Harland, the battery manager, that he made further trials from time to time. At present he would take more than we can let him have, and he has very few breakages. In this mill also we have been trying the effect of casting shanks in sand, instead of chills, and so far none of these, I believe, have broken.

I have several times attributed the improvement chiefly to better control of the carbon content, which it is endeavoured to keep between 0·8 and 1·0, the latter being regarded as the danger mark. This is borne out by the analyses made at intervals, and while I need not give them in full it may be stated that in 1917 (apart from colour determinations) 15 analyses were made of which only four showed *less* than 1·0, and only two were within the desired limits of 0·8 and 1·0. This year to date twelve analyses have been made, of which only two showed *more* than 1·0, and both were in January, while nine were between 0·8 and 1·0.

Silicon has varied from 0·055 to 0·348, but is usually between 0·1 and 0·2. Sulphur, in the whole 27 analyses has only twice materially exceeded 0·06, and is generally near 0·04. Phosphorus similarly has only twice exceeded 0·06, and that not within the last twelve months, while manganese is somewhat variable, running from 0·21 to 0·72.

Obviously we cannot analyse every battery lining plate used, and sometimes the metal is not manganese steel at all, hence low results.

I may conclude by observing that one of the difficulties met with in operating the plant is the very varied size and shape of shoe shanks in use. Breakages would be minimised by increasing the diameters of shanks and in conjunction with this improvement, three sizes might be standardised so that any falling weight could be suited. Such a state of affairs would constitute a material improvement.

A NEW METHOD OF DETERMINING COPPER.

By James Moir, M.A., D.Sc., F.I.C. *(Past-President).*

(Printed in Journal, November, 1917.)

DISCUSSION.

Mr. John Watson, F.I.C., *(Member of Council)*: There are at least two reasons why the writer felt in duty bound to contribute, however imperfectly, to the discussion of this paper:

Firstly.—At the November meeting, when proposing a vote of thanks to the author, a hope was expressed by me that time might be found to experiment on the method and contribute to the discussion.

Secondly.—There was scarcely any discussion on a previous paper of Dr. Moir's, read in February, 1917.

The first step was to obtain a few necessary reagents, and it may be mentioned *en passant* that the sodium acetate obtained from a local firm bore the label, "Made in Japan." Our Eastern ally is helping us in more ways than one.

Deci-normal Solutions of iodine (re-sublimed) and sodium thiosulphate were prepared. On checking it was found that the iodine solution was slightly weak, this was rectified by dissolving more iodine with iodide to saturate the slight excess of water present, as found by calculation. Then the two solutions checked exactly.

Filters.—I first used double Munktell Swedish papers, moistened, and into this was placed a pulp prepared as recommended. Then I found that I could get an ample supply of waste cuttings of grey filter-paper as used in the cyanide department zinc-gold slime press. The filtrate came through clear, as a rule; but it was found preferable in washing to use the mouth-piece tube of wash-bottle and not the fine jet nozzle.

	Weight taken.	$Na_2S_2O_3.5H_2O$ added	KSCN added	$\frac{N}{10}$ I. reqd.	Cu gm.	Cu %
Pure Electro-type Copper Foil:	I. ·501 gm.	1·952 gms.	·875 gm.	·30*	·4978	99·35
	II. 1·0130	3·962 "	1·800	·30	1·0126	99·96
*Copper Sulphate Crystals:**						
after pulverising,	I. ·250	12·20 cc $\frac{N}{10}$ soln.	·1120 gm.	1·55	·0677	27·08
	II. ·250	12·20 "	·1120	1·10	·0686	27·44
1·250 gm. clean crystals dissolved and made up to 500cc.	100cc = ·250 gm.	12.20 "	·1120	1·60	·0673	26·93
Checked by CN method	100cc = ·250 gm.				·0635	25·42
Bronze British Penny,† 1881, *drilled:*	·2335	36·0cc	·3850	·30	·2269	97·17
Checked by CN method	·2320				·2190	91·39

* Theoretically, should contain Cu 25·15%.

† Bronze coinage contains:—Cu, 95%; Sn, 4%; Zn, 1% (Bloxam).

The results obtained are given, as nearly as possible, in tabular form to save repetition, the author's directions being followed as closely as possible.

The writer regrets that his opportunities have been somewhat disjointed, and that he has not had more time to check more fully this ingenious method. The author is quite modest and frank enough to admit that the method is somewhat tricky, at times. Personally, I think it has the essentials of a good workable method.

Mr. Francis Sutton, of Norwich, author of the well-known standard British work on "Volumetric Analysis," has recently joined the great majority. We have all heard a lot, for many years back, about the progress of chemistry in Germany; but the fact, that Sutton wrote his comprehensive handbook, and has lived to see eleven revised editions called for by the public, shows that chemists of the great English-speaking nations, have certainly not been dormant during the last four or five decades.

The writer hopes that Dr. Moir will persevere with and perfect his invention; so that, when the twelfth edition of Sutton's "Volumetric Analysis" appears, as no doubt it will, a few years hence, we shall see this scheme of our Past-President taking its rank as one of the recognised standard methods for the determination of copper.

THE ESTIMATION OF INJURIOUS DUST IN MINE AIR BY THE KOTZE KONIMETER.

By John Innes (Associate).

(Printed in Journal, March, 1918.)

DISCUSSION.

Mr. H. R. Adam *(Member of Council)*: On reading this interesting paper one is left with the impression that the author should have been satisfied with his clear and able demonstration of the value of the konimeter method for what may be called the "qualitative" examination of mine dust. The results given are insufficient in number, and contain too many discrepancies to establish a claim of anything approaching "quantitative" accuracy. Although the konimeter is capable of showing the weak points of the sugar tube method it does not necessarily follow that the konimeter results are quantitatively correct. One may ask whether, at least in the present stage of evolution of the instrument, regular counting of the particles is not rather a wasted labour, and whether a short statement as to whether the particles were numerous or not, relatively coarse or the reverse, would not be equally valuable.

In his defence of what is obviously the weakest point of the method, viz., the smallness of the "sample," the author is very difficult to follow. Apparently he simply assumes certain conditions of the mine atmosphere, *e.g.*, that it is varying considerably in dust content or that it is fairly constant, and that the currents of air are acting as a kind of mechanical stirrer and making on the whole such an even distribution of dust that 5 cc. or 10 cc. may be considered as representative. Logically, such arguments would lead one to suppose that there was no need of either konimeter or sugar tube, since the conditions as regards dust can be so easily determined. The general surprise occasioned by the results obtained in the neighbourhood of axial water feed machines shows how useless such assumptions are.

TABLE I.

Figures relating to individual spot in the series.			Average figures for the series.			Description.
No. of micro photograph.	Particles under 5 microns per cc.	% of under 5 microns particles.	Average No. of particles under 5 microns	No. of spots	% of under 5 microns particles.	
4	264	97	147	6	96	Axial Water Feed Machines (Drive)
19	622	99	414	12	99	
23	794	95	216	12	97	Reciprocating Machines (Stope)
25	164	93	68	12	97	
10	1000	89	525	6	38	Blasting in stopes
13	212	87	111	6	70	Dust from Crusher House
18	152	93	45	6	93	

With his microphotographs Mr. Innes shows us one spot out of a series of six or twelve, and gives the figures relating to it. He also gives the average figures for the series and in most cases the gravimetric result for the same conditions. I have tabulated in Table I. some of these results, admittedly with the object of showing wide departures from the average, and that an average in such cases is of little value. Thus, when a single spot out of six shows 1,000 particles, and the average is 500, the next spot might show 10 particles per cubic centimeter, or even none at all.

Mr. Innes has not attempted to show any agreement between konimeter and gravimetric results, in fact the general trend of his evidence is that agreement is pretty much a matter of chance. Dr. Moir, on the other hand, found as a rough approximation that in cases where the percentage by number of particles below 12 microns was about 97 and upwards, the weight of these "very fine" particles was about two-thirds of the total weight. In Table II., three of Mr. Innes's results are shown, each with 99% by number of particles under 5 microns, and with the largest particle not above 10 microns, and yet there are great differences in millions of particles per milligram. Mr. Gray's statement that the sugar allows a large proportion of the finest dust to escape may partly explain this, also the fact that even under the 5 micron size the variation in size is sufficient to cause considerable difference in total weight, but such results may also reasonably be used in favour of the sugar tube, which at least takes a fair-sized sample. On the other hand, we find in Table V of the paper three results which

TABLE II.

No. and description of micro photograph.	No. of particles under 5 microns per cc.	% of total No under 5 microns	Largest particle.	Mgms per cu. metre.	Millions per Mgm.
17 Stope (Reciprocating Machines)	69	99	7	2·4	29
19 Drive (Axial Water Feed Machines)	414	99	10	3·0	138
22 Stope (Reciprocating Machines)	633	99	10	2·1	300

show quite a fair agreement between the two methods; these are given here in Table III.

TABLE III.

Description of Series.	No. of Spots.	Particles under 5 microns per cc.	% of under 5 micron particles.	Mgms. per cu. metre.	Millions per Mgm.
Axial Water Feed Machines (Drives)	42	328	99	4·9	67
Reciprocating Machines (Drives) ...	18	230	98	4·0	58
Axial Water Feed Machines (Raises)	66	313	99	3·5	89

Such figures as these indicate that when a larger number of spots is considered agreement is better.

For the present, therefore, the most obvious arrangement would be to utilise both methods: thus it might be found possible to determine by means of the konimeter the general character of the dust from typical places, and modify the gravimetric results accordingly.

Apart from the question of quantitative accuracy, however, Mr. Innes's figures and microphotographs are of great interest: thus if further investigations support his results that axial water feed machines create practically as much fine dust as the reciprocating type, the conclusion is that by this method of application of the water the particles are not wetted. It has been suggested that this may be due to the air blown in with the water, but it would be interesting to know the effect of small additions of, say, soap solution to the water used, a very minute proportion of soap or "soluble" oil in water has a very great effect on its wetting power, and seems to be related to the great decrease in surface tension which results from such additions.

It is unfortunate that only one specimen vaguely described as blasting dust has been included—one would like to have seen samples from stopes taken at such an interval of time after blasting as intervenes before the new shift begins.

It may seem that in this contribution to the discussion too much has been made of those figures showing inconsistencies in the samples, but since the author suggests that the konimeter may be used as a source of evidence in cases of broken regulations, etc., the importance of carefully defining the limits of the method is clear. Also the more the method is criticised the more likely it is to be improved, and there is not the slightest doubt that whether the method becomes official or not the evidence obtainable by its use, if considered with due regard to its limitations as regards quantitative accuracy, will be of the utmost value.

Mr. E. M. Weston *(Member of Council)*: Mr. Innes is to be congratulated on the painstaking and thorough manner in which he has carried out his investigations, on the manner in which he has presented his material, and especially on the splendid microphoto reproductions.

The first point in his paper calling for notice is his statement: "Then the one type of dust is of vital importance while the existence of the other is merely of academic interest." He has already defined dangerous dust as dust under five microns in diameter, and he evidently believes with the authors of the 1916 Miners' Phthisis Prevention Committee Report, that the boundary line might be placed at two microns. Mr. Innes's paper gives me the opportunity to voice a conclusion that I arrived at some time ago, after reading the 1916 report.

I very much fear that there has been a tendency to jump at conclusions which may prove most dangerous and fatal to progress. I think we need carefully to consider the evidence and examine the line of reasoning on which this conclusion is based. A layman is of course a fool and is looking for trouble if he differs from medical men on physiological facts; but any one is entitled to examine the line of reasoning by which conclusions are drawn from published facts.

Let us ask ourselves seriously and without prejudice, what evidence we have for the strange and remarkable conclusion that dust of diameters from one twelve-thousandth of an inch to say one twelve-hundredth of an inch is harmless. Let us just look at the matter in a general manner. Nature, it has been said, abhors a vacuum: but it is most true generally that nature abhors and ignores sharp boundary lines. Science has been busy these last fifty years in abolishing them. We enquire what is the evidence on which this rigid boundary has been fixed, and it seems that it is merely negative.

A miner dies of phthisis some time after he has left underground work. His lungs are examined, and the majority of particles of dust present are found to be less than two microns in size. We venture to ask was death, in cases of pure silicosis, caused by the mere weight of dust in the lung, or by the restriction of active area caused by the result of scars. If so, is there not at least a possibility that this finest dust is residual dust, remaining only because, owing to its size, expectoration has not succeeded in removing it. There is not one particle of evidence, I contend, that the millions of particles of dust to which this ridiculous adjective of "coarse" has been applied, have not during his underground career entered the unfortunate miner's lung, and have produced these wounds and the resultant callous-like tissue, and been afterwards ejected. Have not these particles sharp edges? Cannot they cut? Have we any evidence that particles above the magic size of two microns cannot reach the active surfaces of the lungs? There may be such evidence; but at least I do not think it has been made public. It is true our two micron particles are endowed with the Brownian movement, and being of the finest size they penetrate furthest. I wish most seriously to press the point that we need far more *positive* evidence than has yet been made public before we are asked to stake our lives on such a far-reaching generalisation. Personally, I am not satisfied that any sharp dust that will remain suspended in the air is harmless. Negative evidence is not enough. The onus is upon those who make such assertions to produce positive evidence proving, not that fine two micron dust is deadly, or, as we admit, the most deadly, but that five to twenty micron dust is harmless.

Even assuming the truth of this division, Mr. Innes's konimeter results have shown that mine dust does not vary so much after all, as his percentage of "dangerous" dust varies apparently only from 70% to 95%, which is not nearly of as much importance as he seems to regard it, and certainly does not render the gravimetric method useless. His results are most valuable in showing that practically all mine dust is "dangerous," and that even under present conditions the air of an ordinary mine contains enough millions of sharp particles to kill rapidly once nature's protective devices are weakened. We know the official view is a most comforting one, and heretics who question this are not in favour. I have already, in my contribution to Dr Pratt Johnson's paper, stated what many know to be the truth and what I believe to be the only real remedy. The facts Mr. Innes brought forward about certain water-fed machines apparently have caused some stirring of the placid waters; but it has really long been known that the mist they cause when any excess of air is turned on contains much dangerous dust.

It seems that the konimeter is valuable rather to produce qualitative results since the system of taking very small samples must depend for its success, as others have pointed out, on the general diffusion of the dust particles in the air. Very near rock drills the currents set up by the air exhaust, make the distribution of dust irregular. In other places we would expect the dust to diffuse from the sources of its production and only in broad air currents and large air spheres would the contents be uniform. The ease and rapidity with which samples can be taken make it an invalubale aid to inspection, but I do not think that gravimetric results are rendered unnecessary.

In my contribution to Dr. Pratt Johnson's paper I pointed out the danger of using dust sampling results for comparative purposes, and stated that there was a danger of this being done to such an extent as to make the system become a farce. I did not explain all the factors that make the comparison of any two dust sampling results a most difficult matter unless all the circumstances are known. I did mention the personal factors. Mine officials are only human and do not care to have high averages returned from their sections, when they are honestly doing everything that lies in their power to keep conditions as healthy as possible, if they knew that averages may be used against them.

Let me first point out the circumstances that influence the results of sampling, and then deal with the system of preparing results for consideration and publication. Under the present method of air sampling results are affected by the amount of development in relation to other work that is going on, more especially if reciprocating machines are used. A mine pushing development will show higher averages than an ordinary stoping mine. If machines used in stoping cause more dust than hammer boys, then in a year of shortage of native labour, average dust results may be expected to be higher. Then again, as from visit to visit, the time of sampling will affect the result. In hammer stopes while the natives are starting their holes, even if the miner takes the trouble to try and make them splash on water from the start, the dust contents of the air will always rise to a dangerous level, and this, of course, occurs early in the shift. Later on the dust contents fall. The same thing applies in hand labour development ends, winzes and raises. In machine stopes and development ends, dust sampling results have long ago shown that during starting a hole, even if the water jet is properly used, the amount of dust in the face rises to about 8 mgm. or over. The other day in a test with two reciprocating machines, and a mine captain turning a jet on one hole and the shift boss doing the same with another while collaring, the air showed 10 mgm. Now, unless it is otherwise arranged it is a matter of chance whether the dust sampler arrives at the face when a hole is being started, or later, when the dust has fallen to 3 to 4 mgm. I have frequently seen the sampler go round and get low results everywhere in machine faces on one visit, because no machines were collaring; while on the next visit perhaps, the average was high because most of the machines happened to be starting their holes. The presence or absence of rock drillers from their working face also affects the results. Even a diligent miner usually leaves his face for the box between 11 and 12 a.m., and in the absence of white supervision natives produce more dust. Hence we know that samples taken at these times may raise the average enormously. One careless man can raise the average 200 . I have mentioned some of the chance factors affecting any sampling. The really vital point, however, is that all averages are bound to be misleading if used or believed to indicate the general condition of mine air unless some of the elementary principles governing other applications of the law of averages are taken into consideration. Mine sampling to ascertain the average gold contents presents a valuable parallel. What would engineers think if men were sent down the various mines of the Rand every day to take samples of reef indiscriminately from a dozen places and then at the end of a year on the results obtained, it were stated that the average grade had been raised or lowered. The air in a mine, as regards the presence of dangerous dust, presents nearly as many variations as does the gold contents of the exposures of reef in the various faces both in regard to time and place as I have shown. A small total volume of air in development ends, and especially in levels below the main air circulation, contains an amount of dust which the most optimistic would call dangerous. The same applies to certain stopes more or less well ventilated, and varying according to the work being done and the time of shift. The great bulk of the air circulating in the mine may contain only 1½ to 2½ mgm. which would not usually be called dangerous. Ore bins and loading stations in shafts are centres of dangerous dust production that help to pollute the main air currents. The careless man in all places allows dust production over the average, and any shortage of water or disregard of its use, means dust production. Now, it is obvious that the average result from any sampling or the results from sampling over any period depends, apart from the other factor, on the relative numbers of the samples taken in the "good" places to those taken in the bad ones, and by altering the relative numbers results will be either high or low.

To get a true idea of the conditions, the classification of the working and travelling faces, their relative numbers, their number in relation to persons working in them and exposed to dust, the relative number of samples taken in each should be recorded. The position as it appears to me to-day is that thanks to dust sampling and the measures taken to improve ventilation and provide and use water, and to work mostly one shift only, we have made great advances. We have very greatly reduced the number of persons exposed to dust and fumes after blasting; but there are still cases where these are breathed with fatal effect. Secondly, we have reduced the amount of dust produced in our mines by perhaps 85 to 90 . We do not, however, yet know if the 10 or 15 as generally distributed in the mine air will disable men breathing it during their working life. The probability, from past recorded results of worse conditions is, that it will take a much longer period than before for dangerous results to accrue, much depending on the condition of nature's defensive devices. Dust sampling, however, has shown us that in dealing with this factor as it concerns the individual miner, we must disregard averages; because we know that certain workmen, more particularly developers, trammers in development drives on lower levels, skipmen and some hand stopers have to breathe during a portion or portions of their working hours air which contains a proportion of dust which we know to be really dangerous.

It does not in the present state of our knowledge seem possible to improve these conditions very greatly, however hard we may try. The obvious remedy is to provide those exposed to such conditions with some protection such as a respirator which can protect them during the time bad conditions prevail.

I think the miners, whose lives are concerned, and the public of Johannesburg should know that the official view is that everything is well, and the air down our mines such that no one need fear contracting phthisis. They should also know that a respirator has been invented and offered to the industry (leaving the matter of any reward entirely in their hands). The respirator can be worn with ease, and can be breathed through as can be tested by anyone present to-night. Tests have shown that it will stop practically all dust. Official quarters have made up their minds apparently that it is not needed, and that even if it were no one would use it; despite the facts that in the past hundreds of miners endured the stifling effect of the old style respirators. Mr. Kotzé conceived the idea that he would arrest and count all the dust by making it impinge with high velocity on a sticky surface. I proved that if one made the dust laden air we have to breathe impinge with a much lower velocity on a number of sticky surfaces, the same result would be achieved, and a respirator made through which one could breathe freely. The industry has, however, no use for the second device.

I might say that Mr. Toombs made a variation of my respirator in the sense of its being more compact, which he has tested himself, and which he says he found to stop practically all dust. As it is of most ingenious construction, I would like you to look at it. (Handing round respirators for the inspection of members.)

The body of it is carried in the pocket or attached to the coat, and the wearer's nose is either clamped or has cotton wool in it, to prevent his breathing through the nose—in a similar manner to the "Proto" apparatus, or tubes may be placed in the nostrils also.

Mr M. Weinbren *(Member)*: Dust samplers eagerly looked forward to Mr. Innes's paper, as they felt it would be an excellent opportunity to finally decide whether the konimeter should supersede the tubes or not. Now that the opportunity has come the enthusiasts on both sides should not rest until a final decision is obtained.

As well as the advantages of greater accuracy, and the time and labour saved by the konimeter, there are certain other advantages which only appear when one compares the two methods of sampling step by step.

(A) In the tube method the sampler has to set up his cumbersome apparatus at one particular place in the stope to get an average result, as it is seldom that more than one sample per stope is taken, but it is difficult to say where this one place should be without going up and down the whole face to see what is taking place at the various benches, and as the tube sampler cannot find time to do this and yet take an adequate number of samples, the result is that the one sample per stope seldom represents the average conditions. Having set up his pump and tube, the tube-sampler is forced to remain near his apparatus during the whole period of sampling as it is not safe to trust the natives to do the counting and, therefore, unless he has to go to the next level he will not have examined the water appliances at the various machines. On the other hand, the konimeter sampler, knowing that one sample per stope is useless, goes down the whole length of the face to take a sample at each machine, and at other places where lashing and tramming is in progress. Thus a thorough idea of the conditions in the stope is obtained, and he is better able to assist in enforcing the water regulations.

(B) *The Moral Effect.*—Dust will not be reduced to a minimum until the interest of the miners is fully aroused, the konimeter can be used as a direct agent in this direction. The average miner has a very hazy idea as to what is happening when a sugar tube sample is being taken. Being told that a milligram of dust was caught in the tube only helps to obscure his ideas, for few know what a milligram is, and moreover the tube, with the exception that the sugar becomes moist, has the same appearance after the sample has been taken as before, and what the miner does not see, he finds difficulty in realising and believing. With the konimeter samples it is different; a perfectly clear plate is shown to him and when the piston is released the dust spot may be seen, and he can, if he so desires, subsequently see the number of particles counted. The miner thus gets a far better idea as to what is taking place. Many a time I have seen miners who were usually apathetic towards the whole business, become electrified with interest, once he has seen the dust spot and grasped the idea.

While on this point, it may be well to mention the system introduced on the Robinson Deep of giving each miner a sampling sheet of his stope after it has been sampled. The sheets are marked with the places at which samples were taken, the actual results, and a few explanatory remarks and suggestions. This system should work well by keeping up the miners' interest in the scheme.

(c) *Contamination and Accuracy.* — In any operation, the more complicated it is, the greater is the probable error, and in comparing the sugar tube with the konimeter the following points have to be borne in mind.

(1) Allowance has to be made for the original amount of dust in the sugar. This is a serious source of error as only one blank tube is run for several pounds of sugar and furthermore any error made is multiplied three-fold, as only one-third of a cubic metre is taken, yet the results are returned per cubic metre.

(2) Allowance has to be made for the weight of the filter paper ash. Here again the error is multiplied by three.

(3) Inaccuracies in taking the sample :

(*a*) Pumping at different rates will give different results.

(*b*) Different grades of sugar give different results.

(*c*) Different amounts of moisture in the atmosphere will give different results, as the sugar will clog to different extents.

(*d*) Variations in the pump between periods of calibration. It may be possible for the Chamber of Mines samplers to calibrate their pumps daily, but that is out of the question for the individual mine samplers.

All these disadvantages are obviated with the konimeter, and the chances of contamination in changing the slides are negligible. My own experience during the last six months bears out the author's figures for the number of samples spoilt. To illustrate this point a series of samples taken in the "Chris." shaft on the Robinson Deep may be mentioned. The conditions were particularly unfavourable. There were thirty natives working in that confined place with nineteen heavy jack-hammers, and as well as the "rainy" condition of the shaft, fountains of water were continually being shot up into the air by natives blowing out holes, and despite these disadvantages, only four out of thirty-two spots were spoilt, and a remarkably consistent series of results were obtained. It would have been practically impossible to obtain reliable results with the tubes under such adverse conditions. Such samples as dust due to hitching, to reef sampling, and dust in the vicinity of the collar of a hole are very easily taken with the konimeter, whereas by the other method they are taken with the utmost difficulty.

Unfortunately I am writing this from Cape Town without any results available, but should the author desire to see them I feel certain the manager would supply them.

(D) It has been stated that one cannot always obtain a dust spot. This difficulty is very easily overcome after a little experience. Should the sampler be working in a place where obviously there is very little dust present, he should always look at the plate by holding it up to the light to see whether a spot has been formed with 5 cc. of air. If no spot is visible 20 cc. or even 40 cc. may be taken as the sample, and thus a spot will always be obtained. If in a place which is obviously dusty no spot is obtained, then obviously the mechanism of the konimeter is at fault, but that cannot be put down as an objection to the konimeter.

Several series of samples were taken in travelling ways on the Robinson Deep, the results ranging from 10 to 25 particles per cc. and yet none of the spots were missed. Check samples were taken by Mr. Atkin and he obtained the same results. One series of samples taken on a travelling way ranged between 5 and 10 particles per cc. In this case 40 cc. were taken per sample. An attempt was made to preserve these samples, but owing to cover-glasses being unobtainable it was found impossible.

(E) Dealing next with the labour involved in counting, it may be stated that a whole plate of samples can be counted in the time it takes to dissolve the sugar when assaying the sugar tube sample, and dissolving the sugar occupies a very small portion of the time taken up in assaying a tube. Under the above heading however comes the only objection to the konimeter, which is so serious that it needs to be remedied before the konimeter can be claimed as an absolute success. This is the effect on the eyes. Unfortunately very few mines have so far adopted the konimeter, or have done extensive work with it, and it will therefore be difficult to get corroborative evidence. Mr. Innes, I understand, has only counted a portion of the samples taken on the Ferreira Deep, while during the last six months he has employed two different samplers, so that neither of them has done very much counting over any considerable period, and their eyes will not yet have felt any permanent strain. My own experience has shown that six month's counting, averaging roughly an hour to an hour and a half per day, has had so serious an effect on the eyes, which there is every reason to believe were quite normal, that I am now forced to wear glasses. I have it on good authority that it is due to the microscopic work.

It would perhaps be only fair if my method of counting were mentioned.

The angular or sector method of counting was used for samples up to 100 particles per cc., and the square method for heavier samples. It was found that the angular method for heavy samples threw too big a strain on the eyes due to the large number of particles one had to count, and to have used a smaller angle than 18° would have meant increasing the chances of error. Artificial illumination was adopted and the microscope used was not an expensive one, but assuming that artificial light may have increased the strain on the eyes, and allowing another six months for this, it is still obvious that if one's eyes are to be affected within a year, very few people will be found to undertake dust counting.

An attempt was made at the Robinson Deep to overcome the counting difficulty. The idea was to throw the spots magnified to such an extent on to a screen that there would be no strain on the eyes. The necessary apparatus was eventually found, but a great deal of experimental work was necessary before results which were at all satisfactory, were obtained. It may be mentioned that with the consent of the School of Mines authorities, couplings were made to fit the apparatus on to the lantern in the hall, and it was hoped to have given a demonstration of the method when Mr. Innes read his paper, but unfortunately it has had to be postponed until my return. The apparatus simply consists of a microscopic attachment to a lantern by which it is possible to magnify each millimeter spot to as much as 5 ft. in diameter. The best effect however is obtained with a magnification to about 2 ft. in diameter, the screen used being a sheet of Whatman's drawing paper. Originally, a ground glass plate, as suggested by Mr. Innes, was used and the counting done from the back of the plate, but subsequent experiments showed that the particles were better defined on the drawing paper, there being no difficulty in counting from the front of the screen. The advantages of this method are that there is no strain on the eyes, a better idea is obtained of the shape of the particles, and the different kinds of particles such as oil are easily differentiated. The disadvantage is that it requires two men to do the work, one to look after the lantern, the other to do the counting. The time taken to count the samples is about the same as with the microscope. The great point, however, is that it may be possible to do away with counting entirely, as one of the Chamber of Mines samplers suggested, by running off a series of photographs from the screen and then judging the number of particles in other samples by comparison. Further experiments are necessary on this point.

I have here the results of two of the monthly surveys on the Robinson Deep. It may be mentioned that it took almost three months to make a complete survey of the Robinson Deep with the sugar tubes, the assaying being done off the property, while with the konimeter it is possible to make a complete survey every month, as well as take about thirty samples of CO_2, the sampler being personally able to obtain the results on the mine.

DECEMBER SURVEY.

Type of Work	No. of Samples.	Particles per cc
Holman machines in stopes	125	120
Hammer stopes	52	60
Jack-hammer stopes ..	20	86
Leyner (development)	52	600

JANUARY-FEBRUARY SURVEY.

Type of Work	No. of Samples.	Particles per cc.
Holman (small) in stopes	132	100
Hammer stopes .	32	57
Jack-hammer stopes	32	110
Leyner (development) ..	61	622

The results given for development are for all types of development with Leyner machines, as there were not enough winzes and raises to classify them separately. It may be mentioned, however, that the heaviest samples were found in winzes. It will be noticed that the figures given by Mr. Innes for reciprocating drills are almost identical with the Robinson Deep figures. The difference in the figures for the jack-hammer stopes in the two surveys is probably due to the fact that a larger number of jack-hammers were started up during the month of January the natives working them being new to that type of machine.

In conclusion, I should like to appeal for a higher status for the dust sampler, and to do this it is not enough to say that the sampler shall rank as a shift boss or as any other such official, but the status should be raised through the samplers themselves, by only appointing men who have a knowledge of the incidence, causes and history of phthisis, and who understand mine ventilation. In this way a small army of investigators would be at work instead of an isolated one here and there.

I wish to thank Mr. Innes for the assistance rendered me when first we started koninmeter sampling, and I also desire to thank the management of the Robinson Deep for permission to use the figures I have quoted.

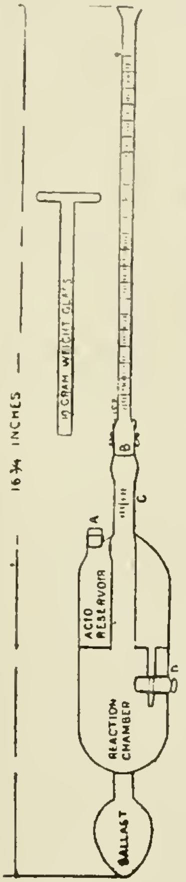
The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

A Simple Method for the Determination of Calcium Oxide in the Presence of Calcium Carbonate.—"Slake 1 gm. of the lime sample in a small amount of water in a graduated flask and add 2 gm. NH_4Cl dissolved in 150 cc. 55% $CaCl_2$ solution. After frequent stirring for 15 minutes add two portions of 0·5 gm. NH_4Cl 1 minute apart during constant stirring. Dilute the contents of the flask to the mark with the 55% $CaCl_2$ solution and titrate an aliquot of the clear solution against 0·2 N HCl with methyl orange as indicator."—N. Busveld, *Tidskritt Kem. Farm. Terapi, 14*, 143-4 (1917).—*Chemical Abstracts*, Dec. 10, 1917, pp. 3196-7. (J. G.)

Modification of Pelouze's Method for Estimating Nitrates.—"In carrying out this method the weighed sample is heated with a measured volume of standard $FeSO_4$ solution containing a little free H_2SO_4, and the unchanged $FeSO_4$ estimated by titration with standard $KMnO_4$ solution. The best procedure is as follows: place 10 cc. N $FeSO_4$ solution and 5 cc. concentrated H_2SO_4 in a flask, cool, attach an inverted condenser and expel the air by means of a current of CO_2. Introduce the sample into the flask and heat for 15-30 minutes. Finally cool the contents and titrate with $KMnO_4$. This method has proved very satisfactory and is especially recommended for the estimation of nitrates in water analysis."—E. A. Letts and Florence W. Rea, *Proc. Roy. Soc. Edinburgh*, *35*, 168-9 (1915).—*Chemical Abstracts*, Dec. 10, 1917, p. 319t. (J. G.)



Determination of Carbonates in Limestone and other Materials.—"The following rapid method of determining carbonates in limestone, etc., gives results agreeing within 0·25% with those obtained by standard methods: The acid reservoir is charged with 40 cc. of hydrochloric acid (sp. gr. 1·15), the graduated stem of the hydrometer is disconnected, and a 10 gm. weight is attached at B. The hydrometer is then placed in a cylinder of water, and the depth of immersion on the scale, C, noted, after which the weight is removed, and powdered limestone is introduced into the reaction chamber until the instrument is immersed to exactly the same point. The graduated stem is now attached, and water is introduced, drop by drop, until the hydrometer is immersed to the zero mark. The instrument is now raised, and the stop-cock, D, is turned, so that acid runs into the reaction chamber. As the carbon dioxide escapes the hydrometer rises, until at the end of the reaction, the reading on the stem at the surface of the water gives the percentage of calcium carbonate equivalent to the carbon dioxide in the sample. A correction of + or − 0·5 is made for each 1° C. rise or fall in the temperature between the two readings. The weight of carbon dioxide left in the flask is counterbalanced by the loss of moisture escaping with the gas."—J. F. Barker, *J. Ind. Eng. Chem.*, 1917, *9*, 786-787.—*Journal of the Society of Chemical Industry*, Sept. 29, p. 1006. (J. A.W.)

Manketti Nuts from South West Africa.—"Manketti or munkuetti nuts are obtained from the euphorbiaceous tree (*Ricinodendron Rautanenii*, Schinz.) found in the South African veldt. The sample examined consisted of fruits ¾ in. to 1 in. in diameter and 1 in. to 1½ in. in length, composed of husks (13%), mesocarp (20%), and nuts (67%). The kernel of the nut formed about 10% of the entire fruit. The kernels contained 4·1% of moisture and 57·2% of a bright yellow liquid oil giving the following values: Sp. gr. at 15° C./15° C., 0·9281; acid value, 1·9; saponification value, 191·5; iodine value, 133·6. From a consideration of its iodine value, insolubility in alcohol, and solubility in light petroleum, it is concluded that the oil belongs to the semi-drying oil group and not, as previously supposed, to that of castor oil. It is not considered to be particularly suited for use in paint or varnish manufacture, while many cheap vegetable oils are already available for the manufacture of soft soap. Its suitability as an edible oil has been shown by experiments of some German investigators a few years ago. Examination of the pulpy mesocarp of the fruit showed it to possess only a moderate percentage of proteins. In view of the small proportion of kernel and difficulty of extratction of the oil therefrom, it is considered that the exportation of the nuts to Europe would not be remunerative."—*Bull. Imp. Inst.*, 1917, *15*, 35-38.—*Journal of the Society of Chemical Industry*, Sept. 29, 1917, p. 1018. (J. A. W.)

METALLURGY

Grinding Ore for Flotation.—"The comparison at Miami lay between rolls, Chilean mills, and Hardinge mills. The Hardinge in this case yielded the more advantageous product. Rolls are perhaps the most efficient granulators made, but their special province is restricted to crushing dry unless the ore is exceptionally free from clayey, or, more broadly speaking, colloidal substance. On the other hand, while rolls tend to choke, as they did at Miami, from too large a percentage of primary colloids, they do not produce as much secondary colloidal material as results from the wet-grinding of ore in other types of comminutors. This is partly for the reason that the time of contact is brief, partly because the method of applying the crushing force involves no shearing, and finally because trituration is entirely avoided. It is interesting to note that the ball-mill, as exemplified by the Hardinge machine in the trials made at Miami, yielded appreciably less pulp of −200-mesh size than the Chilean mill. This indicates less abrasion. Although pre-eminent as a comminutor, the ball-mill nevertheless appears to be essentially a granulator. It is a moot point, since practitioners differ in their opinions, but it seems that the effect in a ball mill is due mainly to what has been called 'radial crushing,' in which respect it resembles the action of rolls, differing, of course, in many respects in the mode of application of that principle. Crushing by impact no doubt takes place to some extent in ball-mills, especially in those adapted for relatively coarse crushing, but the load of balls at any moment is an exceptionally rigid mass, and is caused to move only by disturbance of the equilibrium when the mill is revolving. The result, then, is a tendency on the part of each ball to rotate around its neighbour. The ore particles gripped between the balls are reduced as if caught between the cylinders of opposing rolls. Within the mass of balls there can be no impact of one against another, and the moment that shearing might come into play it would be a case of ball cutting ball rather than of the abrasion of ore particles. Whatever be the explanation of the crushing effect in the ball mill, it is evident that less slime is produced than when the work is done in a Chilean mill. It is not a question of relative merit as crushing devices, but of the kind of product desired by the metallurgist for securing the best possible recovery of metal, and the difference may reside to a large extent in the peculiarities of the ore undergoing treatment. If clay were an abundant constituent, and it were important to eliminate this as rapidly as possible from the crusher, it is conceivable that the Chilean mill would show superior adaptability.

The object at Miami as at all plants where ore is ground for flotation, is to produce as large an amount of exceedingly fine material as possible. Mr. Rickard points out that the decrease in the proportion of sulphide remaining in the tailing at Miami accurately follows the curve of decreasing size of the particles 'until below 200-mesh the recovery of sulphide is seen to be reasonably complete, and the cause of the loss in the tailing becomes due predominently to the inability to save the oxidized mineral.' Mr. Gottsberger states that his aim is 'to produce the maximum amount of material between 60 and 200-mesh.' The product finer than 60-mesh shows 60% under 200-mesh, and although 30·9% of the total pulp, or 45·5% of the −60-mesh, is classed as 'slime,' it is certain that an extremely large proportion of this is actually granular, and hence would be specially well adapted to yield a high recovery of the sulphide by flotation. The significance of this is that sulphides reduced so fine as to approximate the condition of suspension-colloids, as distinct from gel-colloids, are peculiarly amenable to successful treatment by flotation, since they are readily taken up and held in the interface between the oil and water. The presence of gel colloid, apart from any influence it may exert in emulsification, is a deterrent, shrouding the mineral particles, and preventing them from reaching the interface where they would be held and lifted to the surface by the bubbles. The action of the ball-mill, as shown in the operation of the Miami plant, is interesting in this connection. It has yielded a higher degree of comminution with the production of a less amount of slime."—*Mining and Scientific Press.*—(From an Editorial note on an article on the Milling of Miami Ore, by T. H. Rickard in the same issue), October 20, 1917, pp. 560-561. (H. R. A.)

Fused Bauxite for Furnaces.—"In a recent issue of *La Céramique*, M. N. Lecesne describes the following method of preparing bauxite for furnace lining and crucibles: A mixture is prepared of one part of anthracite and three parts of bauxite of an average composition of about 60% alumina, 10% iron sesqui-oxide, and 10% silica, moist as it comes from the quarry. The mass is charged into a furnace lined with refractory material, preferably fused bauxite, and previously heated with anthracite, air being blown through the charge at an initial pressure of about 40 in. water gauge, rising afterward, according to the depth of the charge, though 160 in. pressure is the usual maximum. The temperature rises quickly and the sudden vaporising of the water in the bauxite causes it to break up and to granulate, while the aluminium carbide produced burns and raises the charge to a point at which the silica is volatilized, and the iron, reduced by the action, is expelled by the air-blast as a shower of sparks. The air blast is continued in order to burn off the surplus anthracite and cool the fused mass, which can then be discharged from the furnace and ground, mixed with crude or calcined bauxite as a binder, moulded, dried, and fired in the same way as calcined bauxite. If the fusion is performed quickly, say, in about three hours, the resulting mass will be highly porous, besides containing a sufficiency of unconsumed anthracite to facilitate grinding and briquetting. The fused bauxite will give a refractory material stated to be capable of withstanding a temperature of over 2,000° C. if mixed with some of the same material freed from iron by magnetic separation, and with water and quicklime, the latter forming a binder of silicate of lime. Mixed with bauxite the product is hard but porous, and forms a suitable lining for reverberatory or other furnaces heated with liquid or gaseous fuel."—*Mining and Scientific Press*, Nov. 3, 1917, p. 651. (H. R. A.)

German Iron Ore Supplies.—"The third meeting of the Verein Deutscher Eisen und Stahl Industrieller since the beginning of the war took place in Berlin on December 9, under the presidency of Herr Wilhelm Meyer, and is reported at length in the German newspapers.

French Iron Ore Mines.—The report proceeds to state that the iron and steel industry demanded the retention of the possession of the iron-ore basins of Briey and Longwy, which were necessary to supplement the German iron-ore mines; the life of which was estimated at only from 4 to 5 decades. Enemy countries knew that if the basis of German iron-ore supply was not extended, after the lapse of fifty years the Germans could no longer carry on war with German iron, but would be handed over unconditionally to the enemy. Of no less importance was the protection of the inland market from foreign competition by an approved Customs' policy. The Customs' tariff existing since 1902 was out of harmony with the requirements of a constantly developing industry, particularly in reference to highly-finished products.

Future Exhaustion of Ore Resources.—Prof. Krusch (Councillor of Mines) presented a paper on the question of how far the German iron-ore mines would be able to supply the ironworks after the war. The author first stated that out of the 19,800,000 tons of pig-iron made in the year preceding the war, the blast furnaces were dependent upon foreign ores to the extent of about 50%, whilst the whole of the 700,000 tons of manganese ores had to be imported. He then referred to geological investigations which he had carried out in conjunction with Prof. Beyerschlag in relation to the still remaining inland deposits of iron ore. Taking the output of the mines hitherto, and assuming a natural development of mining without artificial restrictions in the production, the following results were obtained :—The deposits in Lorraine, which yielded 21·1 million tons in 1913, would only last for about a further 45 years; those in the Siegerland spathic ore district (2,700,000 tons in 1913), reckoned to a depth of 1,300 meters, would last 42 years; those in the Lahn-Dill region (1,100,000 tons in 1913) would continue for 66 years for red ore and 32 years for brown ore. These three principal districts furnished about 25,000,000 tons out of the total production of 27,000,000 tons, the possible output of the other localities supplying the balance of 2,000,000 tons being of a limited nature also for the future. Under these circumstances German iron-ore mining would be exhausted in about 50 years and the country would then be entirely dependent upon foreign supplies.

The author proceeded to inquire as to whether certain native ore deposits could be regarded as reserves in the case of a future war, and came to a negative conclusion, having regard to the great consumption and the quality of German ores. The country was therefore dependent upon foreign deposits in order to guarantee its supplies, and the most important country in this connection was France, which possessed 2,600,000,000 tons in the district of French Lorraine alone. In Normandy, Anjou and the Bretagne the ore deposits, mostly proved by Germans shortly before the war, amounted to 5,000,000,000 tons, whilst with the smaller deposits in the Pyrennées, Périgord, Algiers and Tunis, the aggregate reserves of France totalled 8,200,000,000 tons. On the other hand, the German deposits only totalled 2,300,000,000 tons of an average iron content of 30% to 35%, whereas the French deposits ranged from 45% to 50%. As France only consumed 8,300,000 tons in 1913 out of a total production of 21,500,000 tons, that country was incomparably more favourably situated than Germany, and was consequently able to surrender without damaging her own industry the quantity which Germany lacked.

The paper also referred to the necessity for supplies being derived from the Russian district of Krivoi-Rog, Poland, Sweden and Norway, and submitted that a share should also be secured in the extensive and valuable ore deposits in Brazil. In conclusion, the author contended that in connection with the peace negotiations account should be taken of the imperative needs of the German iron and steel industry in the matter of ensuring the supply of iron ores, including manganese, as upon these requirements depended the existence of the industry, the State, and the nation.

The opinions of the author were unanimously accepted by the meeting, and a memorial was prepared showing why the possession of Briey and Longwy should be permanently retained, and the imports of Russian iron ore and manganese also be guaranteed."—*Iron and Coal Trades Review*, Jan. 4, 1918, p. 14 (E. M. W.)

MINING.

Practical Wood Preservation.—"The question of wood preservation at the present time is of greater interest to the coal operator than ever before, because of the scarcity and high cost of steel and concrete. Where rapid construction is required, timber is being used in large quantities, and it is gratifying to note that most of the larger mining companies, as well as a great number of independent operators, are finding it worth while to preserve all their permanent wood construction against decay.

Various time-tested methods that have been found capable of at least doubling the life of timber at a low cost are being utilised, thereby not only eliminating repair timber, but also conserving our forests for years to come.

The method of preventing decay is well established. All investigations have shown that this disease may be forestalled by the permanent disinfection of the wood with an insoluble, non-volatile antiseptic. The injection of creosote oil under pressure has been the usual means employed to preserve ties and wood blocks used in railroad track and street paving where wear and tear are severe and deep penetration is necessary.

For most mining work, however, timber treated by the pressure-creosoting method has not been found practical on account of the delays in getting deliveries of treated timber, the initial high cost, and the fact that the inflammability of freshly creosoted timber is too great. After careful investigation of this subject by many authorities, it was shown upon analysis that the only part of the creosote oil remaining in pressure-treated timber after several years' exposure shows no volatile matter under 275 degs. Cent. After being treated with creosote under pressure, borings taken from timber that has stood in the weather for a period of 10 years show that practically none of the creo sote distilling under 275 degs. Cent. remains in the wood.

In treating mining timber, therefore, the solution of the problem is to use only that part of the creosote oil that is taken off above the temperature of 275 degs. Cent., and to simplify the method of application so that the timbers can be treated at the mines without delay and at a minimum cost.

The method of applying the preservative to the wood should be selected only after considering such factors as to quantity of timber to be treated, the kind of wood, the size and seasoning, and the estimated life of the coal mine where the timber is to be used.

The open-vat method, which consists in immersing the timber, after framing, in a bath of the preservative kept heated to above the boiling point of water, is capable, when properly carried out, of lengthening the life of timber to the point where it fails through wear and tear. The duration of the immersion should be increased in proportion to the dimensions of the timber. Roughly speaking, this is about 10 minutes for timbers up to 2 in. in thickness, and increases five minutes for each inch in thickness greater than that.

Timber that is only partially seasoned should be immersed longer in order to allow the preservative to displace part of the moisture. It is not impossible to treat partially seasoned timber by open-vat immersion if the proper preservative is used. Since the oil most suitable contains no tarry matter to seal the pores, complete seasoning may take place after treatment the same as in untreated timber. It is well known, however, that to imprison sap in green timber by a film of tarry matter or paint will hasten dry rot.

By framing the timbers before treating, good penetration is gained where it is most needed — that is, at the ends and the cuts — thus protecting most thoroughly the parts that rot first. Timber for long-lived developments should be treated in an open vat, especially where it is to be used for tipples, main track ties, and similar purposes.

The equipment necessary for open-vat treating is so simple and easy of operation that many companies have portable vats for this purpose, shifting them from place to place, and treating ties, tipple lumber, and timber for various constructions as required.

The usual form of portable vat consists of a rough wooden box or trough, into which a tin lining is fitted, the joints being soldered to retain the oil. This vat is of a length sufficient to accommodate the longest timbers treated, is wide enough to receive about three timbers side by side, and is approximately 18 in. deep. A drain board is fitted up to slope into one side of this vat, and upon this the timbers are lifted after immersion, thus allowing the excess oil to drain back into the vat. The drain board serves a double purpose, as it makes a good roof for the vat when it is not in use.

A heat sufficient to maintain the temperature of the bath at 212 degs. Fahr. in summer or winter is obtained by means of live steam that passes through a system of pipes placed in the bottom of the vat. If a small derrick, with a crab for lifting is added to the equipment, it will be found of great use. By the method just described, three or four men can easily treat from 5,000 to 10,000 board feet of timber per day.

The treatment of structures already erected or in process of erection is often accomplished by brush-coating the timbers with the preservative, which should preferably be heated in cold or damp weather. The joints are coated thoroughly before the timbers are erected, and when built the whole structure is given a thorough painting with the preservative.

Power spraying machines will be found advantageous on extensive work, since they save labour and give good results. Many operators who have employed the brush treatment method have found that the life of their structures has thereby been greatly increased. Double life, at least, may be expected of timber that has been thoroughly brush treated with a high-grade preservative oil." — W. E. HOYT, *Coal Age.* — *Colliery Guardian*, Nov. 2, 1917, p. 848. (E. M. W.)

MISCELLANEOUS.

ALCOHOL FOR FUEL. — "Considerable attention is being paid in Australia to the question of the native production of fuel alcohol and of engines adapted to its use. The first progress report of the special committee appointed by the Commonwealth Advisory Committee of Science and Industry to investigate the subject has just reached this country, as also has a report written by Mr. W. T. Rowe, the chemist to the South Australian Department of Chemistry, and published as Bulletin No. 8 of that department. These reports run on closely similar lines, the main aspects of the problem with which they deal being the design and manufacture of the engine, the supply of alcohol, and the methods of denaturation.

The committee, like Mr. Rowe, begin with a discussion of the advantages of alcohol as a fuel for internal combustion engines, and proceed to explain the reasons that have decided them to devote their attention primarily to the design and manufacture of stationary rather than motor-car engines. They consider that much can be done to familiarise people with the use of alcohol as a fuel by exhibiting alcohol engines at work at agricultural shows and other exhibitions in Australia, and they propose either to purchase or to have constructed an engine or engines for demonstration purposes. In this connection the Secretary of the Alcohol Motor Fuel Committee of the Imperial Motor Transport Council, who are co-operating with the Australian Committee, will be glad to receive at 39, St. James's Street, London, S.W.1., any available information as to the cost of efficient alcohol engines and the probable date of delivery. A small stationary engine of 5 to 10 h.p. would be preferred, but if it is impossible to obtain delivery of a suitable engine at a comparatively early date a complete set of plans might be purchased with a view to the engine being constructed in Australia.

Production. — In the opinion of the committee the supply of alcohol is likely to prove a much more difficult problem than the design of engines for its use. The most economical source for its production at present is said to be molasses, but even if the whole available supply of molasses in Australia were used for the purpose it would be sufficient for the supply of only about 4,000,000 gallons per annum, whereas the annual imports of petrol are in the neighbourhood of 17,000,000 gallons. The average quantity of molasses available annually in Australia for distillation is about 50,000 tons, of which about 12,500 tons are now used for that purpose. The remainder is largely wasted. The present price of alcohol produced from molasses is about 1s. 9d. a gallon, *ex* store in Melbourne. It appears unlikely that any considerable quantity can be made in Australia from either raw or waste materials not at present utilised. The most important of these materials are waste timber, grass-tree, prickly pear, waste fruit, and straw. The prospects of producing alcohol from cellulose, such as waste timber or straw, on a profitable basis do not seem encouraging. Failing the utilization of raw or waste materials it will be necessary to grow special materials for the purpose. Of these the committee regard maize, wheat, barley, potatoes, and beet as the most promising, though they are not yet able to give particulars of the cost of manufacture from these sources.

Mr. Rowe thinks that in South Australia potatoes offer the best prospects, but he points out that the crop in the best years, about 33,000 tons, even if all converted into alcohol, would yield only 760,000 gallons, or less than half the present consumption of motor spirit in the State.

Denaturation. — The committee state that the denaturants at present required for industrial methylated spirits (2% of wood naphtha and ½% each of pyridine and mineral benzine) cost 1·74d. per gallon of alcohol, and they regard an alteration in the regulations as desirable if alcohol is to be available at as low a price as possible. Their suggestion that 1% of pyridine only, which would reduce the price of denaturants to 0·9d. per gallon of alcohol, would suffice has not been approved of by the Excise authorities. They are collecting data with the object of finding a cheap and efficient denaturant which can be produced in Australia, and they express the hope that the authorities will deal with the whole question in a liberal spirit, since otherwise artificial restrictions in the way of the extended use of industrial alcohol will be greatly increased.

Mr. Rowe also insists that the first step towards the production of alcohol on a large scale is a revision of the Excise regulations, so as to provide a system of methylation better adapted to a motor spirit than that now in use. He suggests that benzol or petrol, or both, should be allowed for methylation purposes, and that the redistilled condensate from Pintsch gas manufacture would make a cheap and effective denaturant. This liquid contains a large proportion of benzol, and like it will mix with alcohol in all proportions. It would, he says, certainly fill the bill as far as nauseousness is concerned, and it is a powerful fuel as well."—*Times Engineering Supplement*, Sept. 28, 1917. (H. R. A.)

EFFECT OF SULPHIDE ON CEMENT.—"Cement is materially affected by the presence of sulphide, whether in the original material or in the water employed for mixing. J. C. Witt has conducted elaborate experiments on this subject under the auspices of the Bureau of Science at Manila, Philippine Islands. His conclusions, printed in the *Philippine Journal of Science* (Vol. 9, sec. A, No. 6) are that, (1) The setting time of cement is greatly modified by the presence of sodium sulphide. With low concentrations the set is retarded, but, after reaching a maximum, further additions accelerate the set. In general, the cements highest in iron content are most sensitive to this influence; (2) there is a decided decrease in tensile strength. The percentage-loss varies with the concentration of the sulphide and with the iron content of the cement. The briquettes appear normal in every other respect, except in colour. There is no cracking nor distortion of any sort; (3) in most cases sulphide may be present in concentrations up to 1 gm. per litre without causing the tensile strength to fall below the U.S. Government specifications; (4) certain results indicate that a colloid is formed by the action of sodium sulphide on the iron in the cement; (5) based on the results of both chemical and physical observations, the following explanations of the decrease in tensile strength are offered: (*a*) The precipitated colloid forms films of inert material through the cement and interferes with the cohesion; (*b*) When the colloid is precipitated a portion of the dissolved calcium hydroxide is removed from solution. Since the latter substance is a very important factor in the strength of cement, the strength will be lowered when some of it is removed; (6) It is probable that other factors influence the effect of sulphide on cement. Among these are the fineness of the cement, the temperature at which it is mixed, the proportion of water used, and the amount of dissolved calcium hydroxide."—*Mining and Scientific Press*, Nov. 17, 1917, p. 725. (H. R. A.)

THE ALTERATION OF DOLOMITE NEAR POTGIETERSRUST.—"A succession of geochemical changes are suggested to account for the removal of Mg from a dolomite and its enrichment by Ca. The following method of discriminating between dolomite and calcite is given: Place the rock in $FeCl_3$ solution until the calcite is stained light brownish yellow; wash under the tap till adhering $FeCl_3$ is removed. Allow to dry and expose to H_2S. A black stain is formed where calcite was present."—R. B. YOUNG, *Trans. Geol. Soc. S. Africa*, *19*, 57-61 (1916.—*Chemical Abstracts*, Dec. 10, 1917, p. 3216. (J. G.)

LIFE OF CAST-IRON PIPE.—"Cast-iron, especially in the form of pipe, seems to last longer than any other form of steel or iron. Some remarkable records have been reported. There are records of pipe in use in Europe for over 200 years. In this country, and particularly on railroads, such long-time service is not recorded because of the limited time that these pipes have been in use. In the early years of American railroads, water-service was given with pipes of less than 3 in. diameter and the use of cast-iron pipe in consequence was limited to cases where 3 in. or larger pipe was used. Instances of installations of cast-iron pipe were recently made the subject of study on the Illinois Central railroad. The life of several of these lines has been traced to the present time. The most interesting is that of a pipe-line laid at Centralia, Illinois, in 1855. This was of 4 in. cast-iron pipe approximately 10,000 ft. long. After 12 years of service it became inadequate for the increased consumption, and upon examination it was found to be heavily encrusted. Efforts were made to improve its capacity by cleaning it and relaying a part of it with clean-out boxes at intervals of 100 ft. This provided only a temporary relief and the following year about 5,000 ft. of the line was taken up and re-laid with 8 in. pipe, which is still in service after being in the ground 49 years. The 4 in. pipe relieved at Centralia was re-laid in 1868 at Ramsey, Illinois, where it remained in service until 1903, when it again became too small for the demand and was replaced by 6 in. pipe. Since that time the old 4 in. pipe has been used at various places, principally as drains. Another installation of which authentic records are available is one of 7,500 ft. of 4 in. cast-iron pipe at Little Wabash river, laid in 1857. This remained in service until July, 1893, when it was replaced. The old pipe was stored at Centralia until 1895, when portions of it were re-laid at that place and at Effingham and at Big Muddy. The installations at the last-named places have since been removed but the pipe at Centralia is still in service. No sign of paint can be found on the pipe at the present time and apparently it never had been painted."—*Mining and Scientific Press*, Nov. 24, 1917, p. 764. (H. R. A.)

OXACETYLENE WELDED JOINT IN STEEL PLATES. "A series of tests of the strength of oxacetylene welded joints in mild steel plates has been completed by the Engineering Experiment Station of the University of Illinois, says the *Electrician*. Specimens were supplied by the Oxweld Acetylene Co., of Chicago, and tests were made in the laboratories of the Station at Urbana under three conditions of loading: (*a*) static load in tension (in a testing machine), (*b*) repeated load (bending), and (*c*) impact in tension (in a drop testing machine). For joints made with no subsequent treatment after welding, the joint efficiency for static tension was found to be about 100% for plates ½ in. in thickness or less, and to decrease for thicker plates. For static tension tests, the efficiency of the material in the joints welded with no subsequent treatment was found to be no greater than 75%. The joints were strengthened by working the metal after welding and were weakened by annealing at 800° C. For static tests and for repeated stress tests, the joint efficiency sometimes reaches 100%; the efficiency of the material in the joint is always less. This indicates the necessity of building up the weld to a thickness greater than that of the plate. The impact tests show that oxacetylene welded joints are decidedly weaker under shock than is the original material; for joints welded with no subsequent treatment the strength under impact seems to be about that of the material. The results of these tests have been published as Bulletin No. 98 of the Engineering Experiment Station, copies of which may be obtained without cost by addressing Mr. C. R. Richards, Director, Urbana, Illinois."—*Indian Engineering*, March 23, 1918, p. 163. (J. A. W.)

Abstracts of Patent Applications.

104.17. Francis Evans Moss. Apparatus for separating solid matters from fluids, or fluids from fluids. 17.3.17.

This application relates to apparatus for removing solids from fluids liquid or gaseous—or fluid from fluids of different specific-gravities or viscosities, and consists of a tube with inwardly disposed baffles or pockets for the collection of the material to be separated.

160.18. Ingersoll Rand Company. Improvements in and relating to rock drill cradles and the like. 13.3.18.

This application relates to improvements in and relating to rock drill cradles, more especially mounting, and is primarily designed for fluid operated rock drills of the type known as Jack Hammers.

The object of the invention is to provide a cradle which will maintain the proper alignment of the bit when the drill is at work. The back head of the drill is constructed with a rearward extension rod to form a connecting member between the rear end of the drill with the rear end of the cradle. The front and rear parts of the cradle are connected by means of side rods. The side rods are mounted on a saddle which supports the cradle but which can slide through the saddle piece. The saddle carries a feed nut; and the feed screw, which is rotatably supported by the back portion of the cradle works through the said feed nut. The feed nut has an extension which serves as a means for connecting the saddle to a slotted or link-shaped arm or bar by means of which both the cradle and drill are supported.

261.17. Arthur Cyrus Whittome. Improvements in purifying air. 23.5.17.

The purpose of the invention is to remove the dust from the air in which it is suspended. And a further purpose is to enable the mine air to be sampled for dust, and to destroy noxious gases as well, continuously or for as long a period as is required, and to obtain samples accurately representing the condition of the air in a given section of the mine.

292.17. William Jones. Improvements in means for lubricating the axles and axle bearings of mine trucks and similar vehicles. 6.6.17.

This application refers to an appliance for lubricating the axles of mine trucks by means of two wheels placed inside the track and working in a box containing the lubricant.

The axles of the trucks come in contact with these wheels as the truck passes over them and rotate the wheels, thus bringing up lubricant from the box and delivering it to the axles of the trucks.

The principle of the arrangement has been in common use for many years, but the present invention varies in the detail arrangements, the lubricating wheels being mounted on the same spindle which is placed in vertical guides inside the box and supported on a spring carried bearing, which allows the wheels to be depressed as the truck axles come in contact with them

975.17 John Marriott Draper. Improvements in apparatus for separating substances of different specific gravities, such as fine coal, or ores, or the like. 31.12.17.

This application is for a development of the hydraulic classifying device described in Pat. No. 661.17, J. M. Draper, to which is added a member forming an air chamber, the elasticity of which is intended to take care of fluctuations in feed to the apparatus.

Changes of Address

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

GUYS, C., *l/o* Johannesburg: Durban Roodepoort Deep, Ltd., P.O. Box 110, Roodepoort.

HILTON, H. C., *to* City & Suburban G.M. Co., Ltd., P.O. Box 1026, Johannesburg.

LIBRARY
JUL 22 1920
UNIVERSITY OF TORONTO

THE JOURNAL
OF THE
Chemical, Metallurgical and Mining Society
OF SOUTH AFRICA.

The Society, as a body, is not responsible for the statements and opinions advanced in any of its publications.

Reproduction from this Journal is only allowed with full acknowledgment of the source.

Vol. XVIII JUNE 1918. No. 12.

Proceedings
AT
22nd Annual General Meeting, June 22nd, 1918

The Twenty-second Annual General Meeting of the Society was held in the South African School of Mines, Building, Johannesburg, on Saturday, the 22nd June, 1918, Mr H. A. White (Vice-President) in the chair. There were also present:—

26 Members: Messrs. H. S. Meyer, J. Chilton, J. Gray, C. Toombs, John Watson, E. M. Weston, W. R. Dowling, J. E. Thomas, Profs. G. H. Stanley and J. A. Wilkinson (Members of Council), A. Baguley, J. M. Dixon, P. Friedman, N. M. Galbreath, C. J. Gray, A. King, T. Graham Martyn, P. T. Morrisby, S. Newton, J. J. R. Smyth, J. A. Taylor, A. Thomas, J. Thorlund, J. T. Triggs, G. A. Watermeyer.

8 Associates: Messrs. J. Davidson, B. C. Forrest, L. D. Hingle, J. Innes, J. S. Moir, D. W. Pugh, H. Rasden, H. Ward.

7 Visitors, and Fred Rowland (Secretary).

MINUTES.

The Minutes of the Ordinary General Meeting, held on the 18th May, 1918, as recorded in the May *Journal*, were confirmed.

SIR R. N. KOTZE, KT.

The Chairman: On your behalf, I have a very pleasant duty to perform that is, to congratulate Sir Robert Nelson Kotzé, the Government Mining Engineer, who has been a member of our Society for a number of years, on being made a Knight Bachelor. (Applause.) We consider that this is an honour that he has highly deserved. Although he has been a vigorous and trenchant critic of this mining industry, the technical control of which is very largely represented in our Society, yet that criticism has always been constructive; and, moreover, he has not confined himself to criticism; he has given valuable assistance, and, in connection with dust sampling, has handed to the Industry an instrument which we shall discuss again to-night,[*] but which the consensus of opinion seems to determine is the best instrument for the purpose that has yet been put before the public in any part of the world. (Hear, hear.)

The Secretary read the Annual Report, as follows:—

ANNUAL REPORT OF COUNCIL.

Your Council presents the following report upon the work accomplished during the past year:—

Interest in the activities of the Society is still hampered, very naturally, by the war, the end of which appears to be still far off. Difficulties, due to war conditions, which many of our members experience in their daily avocations, occupy most of, if not all, their spare moments, and even the most ardent supporters of the Society find it hard, at times, to further the objects for which it exists. During the last few months, however, both the attendance and discussions at the monthly meetings have improved, and it is hoped this welcome change in the interest evinced by members will continue.

Our Hon. President, the Governor-General, has authoritatively stated that the Imperial Government considers the Mining Industry of vital importance to the needs of the Empire. As the Society has at all times the interests of the industry at heart, it appeals to the members to further, by every means in their power, anything which will enable the mineral and other products of South Africa, to be worked more efficiently and economically. The price of gold being fixed, it is not possible, as our Hon. Vice-President, Mr. E. A. Wallers, C.B.E., has said, to pass on to the purchaser the naturally increased cost of production. It is possible, however, for our members to devise ways and means for economies in practice and improved methods of work, by which some portion of the increase in working costs may be kept down or even reduced, and the interesting and lively discussions which have taken place recently on Assay Supplies, Mercury, and the Utilisation of Scrap, point the way to further efforts in similar directions. Any descriptions of methods or ideas which at time appear even trivial to those using them in the daily routine of work, will be gladly welcomed by the Council, and those who are unable for many reasons to do their part in the military services of the Empire, are invited to contribute their share to the general welfare of this country in this time of sacrifice, by submitting such ideas freely and without stint. It is one way of helping and the Council hopes members will make full use of the opportunity given to them.

Accounts.—The Finance Committee reports with regret that the annual statement of accounts submitted to you herewith is not quite so satisfactory as that of last year. The revenue shows a further decrease, there being a drop in the subscriptions alone of over £136, while the expenditure, despite every care, shows an increase over last year of £165 9s. 3d. This may be wholly ascribed to the increased cost of printing and stationery owing to the war, while as a result of the many excellent papers and contributions to discussion submitted during the year there is an increase of 84 pages in the size of the *Journal*. The foregoing will explain the deficit on the year's work of £119 9s., which might have been considerably more, but for the excellent support accorded to the *Journal* by those advertising in its columns. The balance sheet shows a slight increase in our fixed deposits, and a decrease of about £70 in the cash at the bank, but the cash assets amply cover all our liabilities. On the whole, while not altogether inspiriting, the accounts may be termed not unsatisfactory under war conditions. We would ask our members to assist the Council by meeting their obligations promptly. The amount of subscriptions outstanding, which are never taken into the accounts, is £1,626 3s., of which £710 17s. represents the subscriptions of 66 members and 31 associates in arrears for 3 and 4 years, the present addresses of most of whom are at present unknown. It has been decided to suspend their membership until the end of the war, when definite action can be taken. Of the balance of £916 6s., an amount of £439 18s. 6d. is at the debit of those known to be on active service, so that the actual amount at all likely to be recovered is £476

	Jun 1895	Jun 1896	June, 1897	June, 1898	June, 1899	June, 1902	June, 1903	June, 1904	June, 1905	June, 1906	June, 1907	June, 1908	June, 1909	June, 1910	June, 1911	June, 1912	June, 1913	June, 1914	June, 1915	June, 1916	June, 1917	June 1918
Hon. Members	5	5	5	8	11	9	13	18	18	16	17	18	21	22	20	23	25	25	26	26	25	23
Life Members		1	1	1	1	1	1	2	3	4	7	7	8	9	9	9	10	10	10	9	9	9
Members	49	81	101	197	284	291	441	639	680	680	683	618	630	731	711	733	618	550	481	463	454	469
Associates	—	—	—	180	238	243	281	338	321	314	342	357	342	402	380	442	396	354	287	272	263	270
Students	—	—	—	—	—	—	—	4	8	4	7	18	20	60	57	22	21	15	2	3	5	2
	54	87	107	386	534	544	736	1,001	1,030	1,018	1,056	1,018	1,021	1,224	1,177	1,229	1,070	954	806	773	756	773

THE CHEMICAL, METALLURGICAL AND MINING SOCIETY OF SOUTH AFRICA.

(INCORPORATED MAY, 1907.)

REVENUE ACCOUNT for the year ended 31st May, 1918.

Dr.

1916-17. £ s. d.	EXPENDITURE.	1917-18. £ s. d.	£ s. d.
	To CHARGES (including Postages, Bank		
(65 10 11	,, Charges, Insurance, etc.) ...	62 12 3	
65 15 9	,, PRINTING AND STATIONERY ...	109 5 0	
10 4 3	,, RENT, LIGHTING AND TELEPHONE...	19 17 3	
596 0 0	,, SALARIES	596 0 0	
5 0 0	,, *Depreciation on Furniture* .. .		
5 13 6)	,, *Excursion, Loss on*		
748 4 5			787 14 6
(7 7 0	,, GRANTS: -Prizes: School of Mines .		6 6 0
21 0 0)	,, *Witwatersrand University Committee* ...		
28 7 0			
	,, TRANSACTIONS : Cost of binding, etc.	22 8 6	
	Less Sales	16 6 0	
			6 2 6
	,, SOCIETY'S JOURNAL—		
(565 5 8	Cost of Reporting, Printing, etc.	730 12 1	
	less Received for Subs. and Advts.		
517 11 7)	after deducting commissions on Advts. and Collections ..	534 17 10	
47 14 1			195 14 3
187 7 11	,, *Balance, Surplus on year's working* ...		
£1,011 13 5			£995 17 3

Cr.

1916-17. £ s. d.	REVENUE.	1917-18. £ s. d.	£ s. d.
	By SUBSCRIPTIONS—		
(601 13 0	Members, current year ...	543 18 0	
95 11 0	do. arrears collected ...	59 0 0	
222 12 0	Associates, current year ...	193 1 6	
44 2 0	do. arrears collected ...	32 12 0	
3 3 0)	Students	1 11 6	
967 1 0			830 3 0
(8 8 0	,, ENTRANCE FEES		27 6 0
18 13 2	,, INTEREST ON FIXED DEPOSITS ...		18 12 6
17 11 3)	,, *Sales of Transactions*		
	,, EXCURSION : Amount collected ...		6 9
	,, BALANCE, being excess of expenditure over revenue for year ...		119 9 0
£1,011 13 5			£995 17 3

BALANCE SHEET, as at 31st May, 1918.

Dr.

1916-17 £ s. d.		1917-18. £ s. d.	£ s. d.
(119 2 3	To SUNDRY CREDITORS	148 15 0	
22 11 6	,, SUBSCRIPTIONS paid in advance	15 3 6	
39 19 0)	MINING EXHIBITION FUND ..	39 19 0	
181 12 9			203 17 6
	,, REVENUE AND EXPENDITURE ACCOUNT—		
(494 7 10	Balance at June 1, 1917 ...	681 15 9	
	Less Excess of Expenditure over Revenue for year ending		
187 7 11)	May 31st, 1918	119 9 0	
681 15 9			562 6 9
£863 8 6			£766 4 3

Cr.

1916-17. £ s. d.		1917-18. £ s. d.	£ s. d.
	By CASH AT STANDARD BANK—		
(223 5 7	Johannesburg	168 6 2	
26 12 8	London	14 10 1	
4 11 4)	,, On Hand, Johannesburg ...	1 0 3	
254 9 7			183 16 6
(405 13 4	,, Cash on Fixed Deposit with accrued Interest	405 13 4	
56 5 3)	,, Cash in Post Office Savings Bank with accrued interest.. ...	57 17 9	
461 18 7			463 11 1
45 0 0	,, OFFICE FURNITURE		45 0 0
102 0 4	,, SUNDRY DEBTORS		73 16 8
£863 8 6			£766 4 3

We have examined the above Balance Sheet and accompanying Revenue and Expenditure Account with the books and vouchers of the Society, and have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the affairs of the Society, according to the best of our information and the explanations given to us, and as shewn by the Books of the Society.

Sgd. ALEX. AIKEN and CARTER, } *Hon. Auditors*

JOHANNESBURG, 14th JUNE, 1918.

(Signed) JAMES LITTLEJOHN, *Hon. Treasurer*

(Signed) FRED. ROWLAND, *Secretary*,
Fellow Chartered Inst. Secretaries.

7s. 6d. Numerous accounts have been rendered for this amount, but so far without the desired response.

Membership.—During the year 29 members have been elected and 13 associates and 2 students admitted. Seven members and 6 associates have resigned while 4 members have died or been killed in action. Lt.-Col. F. J. Trump, D.S.O., Messrs. H. Crumpton, W. Lawrie Hamilton and G. T. Holloway. The total membership is now 773, including those suspended, a net increase of 17 over the number reported last year.

Roll of Honour.—With the return of troops from East and Central Africa, and the departure of further detachments overseas, it becomes increasingly difficult to keep in touch with members on active service.

During the year the deaths in action of Lt.-Col. F. J. Trump, D.S.O., Croix-de-Guerre, and Lt. C. Y. Bruce, R.E., are recorded with sincere regret. Others wounded have been:

M. F. Balfe (now transferred to O.T.C.).

H. F. Donkin.

The honours gained as far as can be ascertained are:

Capt. H. R. Ruggles-Brise, M.C., the Belgian *Croix de Guerre.*

Lieut. E. H. Croghan, Military Cross.

Lieut.-Col. R. S. G. Stokes, D.S.O.

Major G. W. Williams, Military Cross.

Altogether the number of members and associates on active service is, as nearly as can be reckoned, 100, or 13 per cent. of the membership, which is highly creditable. A full list of the names will be published in the *Journal.*

Journal.—The list of original papers and notes published during the year will be found hereunder. The Council feels that members will agree that the standard of the contributions submitted during the year has been exceptionally good. The *Journal* has been issued every month and easily maintains its excellent reputation.

July, 1917. "Notes on the support of the Underground Workings in the Mines of the Rand," by Mr. Percy Cazalet.
"Systematic Packing Underground at the Ferreira Deep Mine," by Messrs. G. Hildick Smith and Paul Selby.
August, 1917. "Mule Haulage Underground at the Durban Roodepoort Deep Mine," by Mr A. P. Roullard.
"A Method for further reducing Cyanide and Zinc Consumption," by Mr R. C. H. Cooke.
September, 15th, 1917. Presidential Address by Mr G. Hildick Smith.
"A Logarithmic Calculator," by Mr D. R. Robinson.
September 29th, 1917.—"Electric Furnace Manufacture of Shoes and Dies on the Witwatersrand," by Prof. G. H. Stanley.
"Electric Steel Melting Plant," by Prof. W. Buchanan.
October 20th, 1917.—"The Application of Diaphragm Pumps to Metallurgical Work," by Mr. L. B. Eames.
November 17th, 1917.—"Fertilizers," by Mr A. Baguley.
"A New Method of Determining Copper," by Dr. J. Moir.
January, 1918.—"The Manufacture of Crude Sodium Manganate for use on the Mines," by Mr. F. Wartenweiler.
"Mercury," by Dr W. A. Caldecott.
February 16th, 1918.—"Separation of Fine Ore before Milling," by Mr. E. H. Johnson.
"Notes on an Underground Spring of Water, containing Manganese and Lithium," by Mr John Watson.
March 16th, 1918. "The Estimation of Injurious Dust in Mine Air by the Kotzé Konimeter," by Mr. John Innes.
"Assay Economies," by Mr. Chris. Toombs.
"Assay Requisites," by Mr. John Watson.
April 20th, 1918. "Further Notes on Sand Filling of Mines," by Mr. C. H. Greathead.
"Gold Absorption by Copper Amalgamation Plates," by Mr. F. Wartenweiler.
May 8th, 1918.—"The Furnace as an Adjunct to the Smithy on a Gold Mine," by Mr. R. Craib.
"The Cementation Process applied to Mining (François System)," by Mr. A. H. Krynauw.
June 22, 1918.—"The Estimation of Oxygen in Working Cyanide Solutions," by Mr H. A. White.
"Notes on the removal of a Vertical Shaft Pillar," by Mr J. Chilton.

Grants.—The usual grant of prizes to evening class students at the School of Mines and Technology was continued, and has been offered again for competition at the ensuing examination. For the first time it is interesting to note that a lady was a successful competitor, as also a clergyman whose daily work is in the training of boys.

S.A. *Red Cross Society.*—The war work of this Society, under the Chairmanship of Prof. Wilkinson, still continues to occupy most, if not all, of your Secretary's spare time, and it is gratifying that the work thus accomplished for the sick and wounded troops has been highly spoken of by men returning from hospitals. The activities in ambulance work continue along the Reef and it is a source of gratification to your Council that its work, which led to the inauguration of the Red Cross Society, has resulted in a keener interest and greater efficiency in first aid. The value of ambulance training to those engaged on mines, is now being appreciated, and the results of that training are being increasingly felt by the saving in days of labour formerly lost. It has not yet been possible to arrange the usual ambulance competitions, but it is hoped that they will be held in August.

Housing of Technical Societies.—With regard to the closer working of the several local Technical Societies, this Society considered a commencement should be made without delay in the direction of a joint housing scheme, by which all the Societies would benefit in having a permanent home and headquarters with lecture hall and offices. Several meetings of the Joint Committee were held during the year, but it is regretted that the majority ultimately resolved that the scheme should be deferred until after the war.

Joint Meetings.—Two joint meetings were held during the year, the first on the 30th June with the S.A. Institution of Engineers, and the other on the 29th September with the S.A. Institute of Electrical Engineers.

Visits. — It was not found possible to arrange any visits to mines or works during the year.

Industries and Research.—The local production of shoes and dies, initiated at the instigation of this Society, is proceeding satisfactorily, while as the result of the efforts of many members of the Society local products are being utilised in almost every department of the mines. The Industries Advisory Board, of which Prof. Stanley is a member, has just issued a report on its work since its inception—an interesting record.

The Scientific and Technical Committee, of which Dr. Caldecott, Mr. Colquhoun and Prof. Orr (members of the Society) are active members, acting in conjunction with the the Advisory Board, is engaged in various ways in investigating the natural resources of the Union and furthering the use of local products.

In this connection attention may be drawn to that excellent publication, "The S.A. Journal of Industries," issued monthly by the Government in both languages, which contains data of much value to all those interested in the progress of South Africa.

Witwatersrand University.—Prof. Wilkinson, your representative on the Committee, has submitted a lengthy report on its work during the past year, which is available to those requiring further details. Briefly it may be stated that donations received amounted to nearly £13,800, which was exceeded in expenditure by £70, that owing to the war it has not been possible to commence the second year's course in medicine; that with regard to the question of the eligibility of students for military service, after a full and frank discussion by the Committee, those raising the question had no solution to offer, but to close down the whole of the colleges in the Union, which the Government would not do; and finally that the development of work in Johannesburg had more than fulfilled the anticipations of the Committee.

During the year 9 meetings of the Council have been held as well as a similar number of meetings of the Finance and Editorial Committees. The attendance at the Council meetings, which averaged 13 per meeting, has been as follows:—

G. Hildick Smith	4	F. G. Macdonald	7
H. S. Meyer ...	8	C. Toombs	6
A. Whitby	5	F. Wartenweiler	5
H. A. White ...	6	F. W. Watson ...	8
J. Littlejohn ...	2	J. Watson	8
H. R. Adam ...	6	E. M. Weston ...	5
J. Chilton	8	J. A. Wilkinson	5
K. L. Graham ...	8	J. E. Thomas ...	4
J. Gray	6	G. H. Stanley ...	5
H. C. Hilton ...	6	W. R. Dowling	2
C. E. Hutton ...	4		

The President left for England on the 30th April by the Kenilworth Castle to proceed on active service, and it is gratifying to learn that he reached England safely despite the serious accident to the steamer.

Although owing to the war it has not been possible for your Corresponding Members of Council to do very much in the Society's interests, yet they are at all times glad to assist members in any way possible when required. The many kindnesses accorded to members when in England by the late G. T. Holloway, who died during the year, will be always gratefully remembered.

Grateful acknowledgement must again be made of the services rendered by the members of the various committees, your Hon. Treasurer, and by the Hon. Auditors.

The Chairman: You have heard the Annual Report of the Council, and you have the Financial Statement in front of you. I beg formally to move the adoption of the Annual Report and Financial Statement.

Mr. W. R. Dowling *(Past-President):* I have much pleasure in seconding the adoption of the Report and Financial Statement. I think, considering the war, that it is very satisfactory.

The Report was adopted *nem. con.*

The Chairman: The Secretary will now read the Report of the Scrutineers on the Election of the new Council.

Johannesburg,
22nd June, 1918.

The Chairman,
Annual General Meeting,
Chemical, Metallurgical and
Mining Society of S.A.,
Johannesburg.

Dear Sir,

We report that we have received from the Secretary, 93 Ballot Papers, and as a result of the scrutiny, find the following to have been elected:—

President.

Mr. H. S. Meyer (unopposed).

Vice-Presidents.

Mr. H. A. White.
Mr. Jas. Gray.
Mr. A. Whitby.

Hon. Treasurer.

Mr. James Littlejohn (unopposed).

Members of Council.

Mr. K. L. Graham.
Mr. John Watson.
Mr. J. Chilton.
Mr. F. W. Watson.
Mr. H. R. Adam.
Mr. F. Wartenweiler.
Mr. C. Toombs.
Mr. E. C. I. Meyer.
Mr. J. R. Thurlow.
Mr. C. H. Greathead.
Mr. E. M. Weston.
Mr. C. J. Gray.

Yours faithfully,

S. Newton,
E. A. Osterloh, *Scrutineers.*
Percy T. Morrisby.

Mr. H. S. Meyer (*Vice-President*): I beg to thank you most heartily for the honour you have conferred on me in electing me President for the ensuing year. I do not think this is the occasion to say anything, but that I am fully conscious of the responsibilities that devolve upon me, and I shall do my utmost to carry them out to the satisfaction of the members and the credit of the Society. All I ask for is the support of the members. Do let us keep the flag of the Chemical, Metallurgical and Mining Society flying, in spite of all difficulties.

The Chairman: Gentlemen, on behalf of the Vice-Presidents, I thank you for the honour you have again conferred upon us, and have to assure you that we shall do our best in the interests of the Society, as far as we possibly can. Coupled with that, I have to propose a vote of thanks to the scrutineers for the arduous labours which they have so successfully conducted.

Mr. John Watson (*Member of Council*): I beg to second the vote of thanks.

The vote of thanks was carried unanimously.

Mr. Sam Newton (*Member*): On behalf of the scrutineers, I have to thank you for the very pleasant remarks that you have made. We notice there is a slight increase in the number of voting papers. We are looking forward to the time when we shall be taxed to our utmost.

HON. AUDITORS.

The Chairman: The next item on the agenda is the election of Auditors. I should like to move a very hearty vote of thanks to Messrs. Aiken & Carter, the Honorary Auditors, for their past work, and to move that they be re-elected.

Mr. John Watson seconded, and the motion was declared carried unanimously.

NEW MEMBERS.

Messrs. John Watson and C. Toombs were appointed scrutineers. After their scrutiny of the ballot papers the following gentleman was declared unanimously elected a new member:—

Cowl, John Pounsney, Kynoch, Ltd., Umbogintwini, Natal, General Manager.

The Secretary notified the admittance by the Council of the following Associates:

D'Oliveira, Rui Humberto, Portuguese Consulate, P.O. Box 106, Salisbury, Rhodesia.

Phillips, Edward Hugh, L.R.C.P. & S. (Ed.), Miners' Phthisis Bureau, De Korte St., Clifton, Johannesburg, Medical Practitioner.

General Business.

MERCURY.

Dr. W. A. Caldecott (*Past-President*): The interest shown, as evidenced by the varied discussions, in the short note upon the use and economy of mercury, is a source of satisfaction to the writer. So much of the discussion has been constructive that little comment is required on the valuable information resulting from the carefully conducted tests recorded by various contributors.

Mr. H. A. White's reference to mercury consumption on the Homestake is hardly analogous to Rand practice, since relatively fine screens are there used in the stamp batteries, with a ratio of water to solids in screen pulp of about ten to one. At the same time, however, Mr. F. Maxwell's results at the Van Ryn Estate show a mercury consumption by tube-mill plate amalgamation much lower than the 0·01 oz. per ton of ore milled cited by the writer, and it appears that, apart from the care and details in practice such as those mentioned by Mr. S. H. Pearce, the factors affecting mercury consumption may necessarily vary on different mines on the Rand, and possibly the percentage of pyrite in the ore may constitute one of these contributing variants. It is unfortunate that the accumulation of mercury as amalgam on plates and in tube-mills and launders constitutes a constantly varying stock, so that the amounts "consumed" for individual months fluctuate greatly, thereby preventing a regular ratio between mercury consumed and gold won by amalgamation each month, and necessitating somewhat lengthy periods of record to ascertain tendencies in mercury consumption.

Mr. McA. Johnston and Mr. S. Newton's remarks upon the volatilization of mercury whilst steaming plates illustrate the attention now devoted to securing healthful conditions of work on mines, and Mr. A. Thomas and Mr. John Watson have recalled constituents, in the shape of moisture and pyrite, present but often overlooked in calculating "mercury due" by retorting amalgam.

Regarding the diverse views expressed by Messrs. E. M. Weston and H. Ward upon the importance or otherwise of maintaining as high a recovery by amalgamation as possible, the position appears to be somewhat as follows: Whilst the cyanide recovery may be only 85% of the gold contents of the tailing pulp, yet the bulk of the gold particles in this pulp are wholly or partially encased in siliceous or pyritic grains. Small free gold particles entering the cyanide works are wholly dissolved therein, or almost so, and hence the extraction of these may be very nearly 100%. At the same time, however, their presence in sand or slime charges raises the value of the solutions leached or decanted off, thereby involving either more washes and precipitation, or higher residues. Hence the recovery, prior to cyaniding, of all free gold practicable by amalgamation without undue cost in plant or labour, appears advantageous and profitable as ensuring a total recovery of this gold at minimum cost, and leaving poor charges to be cyanided, which in turn facilitates low residue values, the equivalent of a high percentage recovery from all sources.

From the data furnished in the discussion, it does not appear likely that either grease tables, blankets, corduroy, jute, or canvas will be voluntarily adopted in place of amalgamated plates if economy in mercury use, including reduction of material barrelled to a minimum, will enable our mercury supplies to last out. In this regard cinnabar has been known for many years to exist near Malelane, in the Eastern Transvaal, and the present price of mercury should be sufficiently high to cause renewed interest in this deposit.

The Chairman: I think it will be agreed that the reply clears up some little confusion that was evidently in the minds of one or two of our members as to the advantage of amalgamating in the mill.

THE FURNACE AS AN ADJUNCT TO THE SMITHY ON A GOLD MINE.

Mr. S. T. Tregaskis *(Visitor)*: in the discussion on Mr. Craib's note, Mr. Laschinger referred to the furnace on the City and Suburban Mine. Some further information may be of interest.

It is not a large furnace, the hearth being 2 ft. 10in. × 4ft. 4in., but a lot of work is got out of it. As easy heat control is of much importance in the varying work of a mine smithy furnace, I adopted the principle of my drill-heating furnace. This also saved the cost of an expensive chimney. Mr. Craib got over this last expense by the aid of forced draught under the fire bars, which should also give him good control and, what is also of importance, enables the furnace to be got ready for work in the least possible time.

Mr. Craib refers to, but I do not think sufficiently emphasizes, the fact that a considerable amount of stock can be put in the furnace at one time, as by that means the smith is kept busy. By doing this and by encouraging the smith with a bonus, I find I can work scrap iron or steel into blooms, weighing 100 lb. to 170 lb., at a cost of 8s. to 10s. per 100 lb. This is allowing 24s. for his use of the hammer during his eight-hour shift, 1s. 6d. per 100 lb. for scrap and cost of coal, with smith's and natives' wages, but not charging for maintenance. We find such material as good, or better, than anything we can buy.

We have met with the same difficulty as Mr. Craib, in making a good job of faggotting wire rope. We have not tried faggotting drill steel, as on this mine everything over a few inches long is welded up and hammered to hand-drill steel.

Mr. Craib has given a representative list of the classes of smith's work that can be most economically done with the aid of a furnace, and there is no advantage in adding to that list; but, with satisfactory heat control, such a furnace can be used for case-hardening economically, and, once having tried case-hardened pins on such machines as plunger-pumps, no one would wish to go back to the plain variety again. We case-harden all our spindles for shaft rollers in our furnace.

Annealing skip connections and such like is, of course, done better in a furnace than in an open fire; but, leaving the material in the furnace to cool slowly should be avoided, as should too low or too high a maximum heat: 850° C., say, cherry-red, is probably about the safest colour to work to. It is a little too high for the probable carbon content of the steel; but it is safer to be a little too high than anything too low.

The cost of maintenance here is not high. The roof and sides last 18 months to two years, and the hearth is made up as required with broken cupels and crucibles from the assay office.

The Chairman: That is a very welcome contribution on the subject, and I hope we shall have some more to add to it. I would ask Mr. Meyer, our President elect, to take the chair while I read my paper.

Mr. H. S. Meyer then took the chair

THE ESTIMATION OF OXYGEN IN WORKING CYANIDE SOLUTIONS

By H. A. White (Vice-President).

Our Proceedings chronicle few attempts to solve the difficult problem of determining the available oxygen in the various solutions in use in the cyanide process of gold extraction.

Mr. Bettel's method (C.M.M.S., Vol. I., p. 276, Oct., 1896) required measurement of gas evolved by boiling under reduced pressure. This needs excessive manipulation and complicated calculations, and the accuracy would probably be impaired in the presence of thiosulphates and sulphites, which are frequently found in some of our mine solutions.

Practically the same idea is made use of in the modified method suggested by Prister in April, 1906 (C.M.M.S., Vol. IV., p. 561). This method also involves boiling large quantities of solution and some careful manipulation of small quantities of gas, nor does it escape the other defects of Bettel's method.

A. F. Crosse has devoted a large amount of work to this determination (C.M.M.S., Vol. II., pp. 396, 419, and Vol. III., p. 2 , and made the necessary alterations in Thresh's well known iodide method. He evaded the difficulty caused by the commoner constituents, including nitrites, but the method would lose in accuracy in presence of thiosulphate or sulphite, which are occasionally present in sufficient quantity to make it entirely nugatory. The method is, however, very accurate where applicable, and its chief defect is the unsuitability for mine work where coal gas is not available.

It is probably the difficulty and laboriousness of these known methods which is responsible for the fact that so little data have been published as to actual oxygen contents of working solutions, the total evidence being comprised in Crosse's and Prister's results that oxygen in solutions leaving extractor boxes is very small, and may be very low in solutions draining from sand vats.

A further inducement towards avoiding this complicated determination is the general conviction, apparently well founded, that our methods of working give ample opportunity for the solutions to absorb all the oxygen required. This would hardly be the case if the closed in system, advocated by Leslie, were adopted, nor is it certainly true where the older methods of sand collection, with imperfect slime separation, are still in use. Furthermore, in the Eastern Rand I have recently discovered the presence of pyrrhotite, which is notorious in other parts of the world for its power of absorbing oxygen with the production of thiosulphates. I propose later on to deal further with the results of oxidation of pyrite, marcasite and pyrrhotite and the evil effect in the solution and precipitation of the gold, and will now content myself by requesting assayers to keep a look out for an apple green ring in cupels used for mine samples, as the pyrrhotite here is associated with the nickel thereby denoted: it is as usual strongly magnetic and can therefore be readily separated in small quantities when the right samples are panned down.

In considering the possibility of establishing an easier and quicker method of oxygen determination, Romyn's method, mentioned by Crosse (C.M.M.S., Vol. II., p. 397) was first considered, with a view of making use of the fair coloration produced by the combination of oxygen with manganous tartrate. It was found, however, that the colour developed was not sufficiently strong and that the weaker results faded too quickly. This colour is more quickly and better developed by adding to 300 cc. of solution 1 cc. of 5N. $MnSO_4$, then 1 cc. of 5N. NaHO; next, after thorough shaking, add 1 cc. of 5N tartaric acid, and when the precipitate has dissolved add a further 1 cc. of 5N. NaHO to preserve the colour as long as possible. The procedure would then be the same as in the next method.

A new colorimetric method of determining Oxygen in working cyanide solutions.

It is a commonplace among photographers that the addition of alkali to a solution of many developers causes a dark coloration, due to formation of quinones, and the use of alkaline pyrogallol to absorb oxygen is a standard method in gas analysis. Careful experiment will demonstrate that there is a close connection between the amount of colour developed and the quantity of oxygen present in the solutions, and that after a few minutes this colour remains fairly steady for some hours if further oxygen is rigidly excluded. Upon these facts the following technical colorimetric method is based.

Apparatus required.—1 dozen (nominal) 250 cc. stoppered bottles, fairly regular in diameter and capacity; one 50 cc. burette.

Chemicals required. Sodium hydrate 2N solution (80 gm. per litre), pyrogallic acid or other suitable developer, brown dye.

Preparation of standards for comparison.—Compressed air, freed from CO_2, etc., by passing through a wash bottle containing 25 NaHO, is blown through two litres of Rand Water Board water contained in a bottle, using a piece of ¾ in. gauge glass in Pohlé lift fashion. The rate should be about half a litre per minute and the time about four hours. The temperature is then taken and the amount of oxygen present calculated from Roscoe and Lunt's tables (Sutton's Volumetric Analysis, p. 302). Or distilled water may be used and the more laborious method given by Sutton may be followed with it, but little difference will be found. Barometer may be taken at 620 mm. and weight of oxygen at 1·429 mgm per cc. at N.T.P. Thus at 21° C. the tap water will contain 7·0 mgm. per litre, and I will assume that figure is found. Fill (with a siphon), completely, one of the 250 cc. (nominal) bottles with the water and add 0·100 gm. of solid "pyro"—the densely crystalline form sold as "Pyraxe" is preferred—and shake all the crystals below the water surface. Then add from a burette, dipping below solution level, 1 cc. of the 2N. NaHO and immediately close the bottle with the stopper in such a manner as to exclude any air bubble at all. Shake up till all the crystals are dissolved, and observe the colour.

This colour is then matched with the solution of a brown dye. I find that "Diamond" brown requires a little acid, methyl orange and a small amount of chromate of potash to match the shade exactly. Make up about three litres of the dye solution, adjusted till another 250 cc. bottle-full of it will exactly match the water tested when both are held together to the light.

A somewhat better match, preserving the tint well on dilution, may be made by using the brown colour obtaining by shaking up a solution of pyrogallol or eikonogen with excess of air till further darkening has ceased. In this case some slight change of tint takes place in a day or two.

Take eight of these nominal 250 cc. bottles and determine the exact capacity, which will be very close to 300 cc., and number 1 to 8. Into No. 1 pour the matched dye solution and insert the stopper without leaving any air bubble. This will represent the amount of oxygen found in the water sample, and the other bottles will have poured into them a proportionate quantity of the dye solution till the series represents 7, 6, 5, 4, 3, 2, 1 and ½ mgm. of oxygen per litre respectively.

If the water sample does not come out sufficiently near 7·0 mgm. per litre, the following figures will have to be varied to correspond; and the capacity of the bottles, if more than 2 cc. or 3 cc. away from 300 cc., will also naturally affect the calculation.

Assuming 300 cc. bottles and 7·0 mgm. oxygen per litre in the sample water—

Into No. 1 bottle pour 300 cc. matched dye solution and fill with water.

Into No. 2 bottle pour 257 cc. matched dye solution and fill with water.

Into No. 3 bottle pour 214 cc. matched dye solution and fill with water.

Into No. 4 bottle pour 172 cc. matched dye solution and fill with water.

Into No. 5 bottle pour 129 cc. matched dye solution and fill with water.

Into No. 6 bottle pour 86 cc. matched dye solution and fill with water.

Into No. 7 bottle pour 13 cc. matched dye solution and fill with water.

Into No. 8 bottle pour 21·5 cc. matched dye solution and fill with water.

In any case the standards are adjusted to represent from 7 down to ½ mgm. per litre of oxygen, and are so marked, preferably, with a diamond on top of the stopper. The four remaining bottles are marked A, B, C and D in the same way.

Any solution may now be tested by plunging a bottle, held vertically, well below solution level, jarring it and moving to allow all air bubbles to escape, then dropping in the stopper while still under solution. The stopper may be given a downward twist when removed from the solution and the bottle will then be sufficiently air-tight for the few moments which elapse before testing. Using a siphon to fill the bottle is obviously a more accurate method, but that given is sufficient and more easily applied. Solutions in contact with pulp must be settled in a two-litre bottle filled in the above manner, and the sample bottle filled therefrom by a siphon.

In testing the sample of solution, the stopper is gently removed with an upward twist so as not to lose any liquid. The 0·100 gm. pyrogallol (of which a sufficient number of lots is ready weighed out) is then dropped into the bottle and shaken down below solution level; 1 cc. of 2N. NaHO is then run in from the burette with point below solution level, and the stopper instantly replaced in such a way that no air bubble is left. After shaking till all crystals are dissolved, the sample bottle is placed between the two standards it more nearly resembles, and thus the oxygen may be determined to 0·5 mgm. per litre. If the colour is not exactly the right tint it will become so within 15 minutes—some solutions retain a sort of purplish tint with pyrogallol for a short time. Adurol, edinol and eikonogen are almost as useful as pyro. Hydroquinone gives a beautiful colour about one-third the intensity; ortol and glycin give a very similar colour of about one-tenth the depth; kachin, pyrocatechin and metol give very feeble reactions. Tannin gives a muddy brown-blue, and is useless, as also are other non-developers such as benzidine, toluidine, di-anisidine and diphenylamine. The developer amidol gives a very deep brown, and, like hydrocœrulignone, gives a measurable colour even with solutions leaving extractor boxes containing very little oxygen. The reaction with leucaniline is too slow and uncertain, though a beautiful tint is shewn with tap water. If pure reduced indigo or methylene blue could be obtained in stable solid form, an easier colour match could obviously be secured and would probably give more accurate results than the above method, which is, however, sufficient for technical purposes, and well within the capacity of any cyanide foreman. Though the solid form of developer is preferable, it is not impossible to make up solutions of sufficient strength, which, however, cannot be kept very long unchanged.

Some Results Obtained.

Solutions in Sumps:

		KCN	Oxygen mgm. per Litre	A	B
Strong (full) .	12° C.	0·027	6·0	4·0	7·0
Medium (½ full)	12° C.	0·021	5·5	5·0	6·0
Weak (¼-full) .	12° C.	0·022	7·5	4·5	7·5
Slime (¾ full)	20° C.	0·012	3·0	4·0	6·0

(A) and (B) refer to the same solutions after passing through the pump on to the sand vats—(A) without extra air added and (B) with an air inlet on suction line near the pump. This air inlet is very simply arranged by inserting a ½ in. pipe the same height as the sump into the suction line, and providing it with a valve which is opened so little that the delivery of the pump is not seriously affected. It will be noted that passing through a well-packed pump does not add to the oxygen content of the solutions. Observe also that the solutions which leave the extractors with less than 0·5 mgm. oxygen per litre very rapidly pick up oxygen, except in the case of the slime boxes, where the solution is warmer and the flow into the sump much more rapid.

Leachings from this point right up to the thirteenth have not yet shown less oxygen than 6 mgm., so that it may be assumed that the more readily oxidizable substances have disappeared.

Observe that the first solution, in which the charge is collected, has had nearly all the oxygen removed, although in the storage vat it is found to contain 7·0 mgm. per litre, and to shew 7·5 mgm. per litre in the solution overflowing while vat is being collected. With this fact may be connected the disappearance of a fair amount of cyanide at this stage, a matter to be dealt with in a later paper.

Solutions leaving Sand Vats.

No. of leaching	Temp. C.	Free KCN.	Oxygen mgm. p. l.	Hr. from opening.	Hr. from collection
1	15	·007	0·5	3	3
1	15	·006	0·5	8	8
2	14·5	·030	7·5	4	26
2	14·5	·030	6·5	8	31
3	12	·030	3·5	10	76
3	14·5	·050	7·5	3	43
4	12·5	·041	7·0	14	81
4	14·5	·027	7·5	11	78
5	13·0	·024	3·0	6	105
5	10·0	·024	7·0	0	97
6	12·5	·024	6·5	5	135
6	12·0	·024	7·0	5	123
7	12	·020	6·5	8	159
7	12·5	·020	7·0	0	140
8	12	·020	6·0	8	182
8	13·0	·020	6·5	13	187
9	14	·016	5·0	10	177
9	12	·015	7·0	2	162

Oxygen in Water.

Rand Water Board water as from tap direct	15·5° C.	5·5
Rand Water Board water as from tap direct	15·5° C.	5·0
Dam water ex. pump	21·0° C.	6·5
Mine water ex. pump	22·0° C.	7·0
Leaving slime collectors	17·0° C.	8·0
Return water sump.	16·6° C.	7·5
Vacuum receiver	14·0° C.	7·0
Three throw delivery	14·0° C.	8·0
Mill steady head vat	18·5° C.	8·0
Water to boilers	49·0° C.	5·0

The Rand Water Board water varies considerably in oxygen contents, occasionally being highly supersaturated. It is surprising to find so much oxygen in the mine water, which has, however, travelled a long way and passed through a pump; a sample straight from the rock would be interesting. The flow through the vacuum receiver on the sand table plant is evidently too rapid for the vacuum (13 in.) to extract the corresponding air, but, curiously enough, the delivery from the three-throw pump extracting this water shows as high a content as any yet tried. With the abundance of air present in mill waters it is curious that some oxidizable matter should still remain, as evidenced in the first treatments of both sand and slime—evidently the rate of air replacement (especially in tube-mills) is greater than the consumption of oxygen for the short time of contact.

Solution in Contact with Slime Pulp.

Storage before Brown vats, transfer completed ..	16·5° C	0·2 (Surface)
Storage before Brown vats, transfer completed ($3\frac{1}{2}$ hours' later)	17·0° C.	6·5 (Surface)
Delivery to Brown vats	16·5° C.	3·5
Brown Vat No. 1	15·5° C.	7·0
Brown Vat No. 2	15·5° C.	7·0
Brown Vat No. 3 .	16° C	7·5
Brown Vat No. 4 .	16° C.	7·0
Storage after Brown Vats	15° C.	6·5

The slime is transferred with cyanide solution from collectors to first storage, air being blown through pipe delivery and also into storage vat at the same time. In spite of this and of the fact that considerable gold has been dissolved, there is practically no oxygen left. During mechanical agitation for the next three and a half hours the air being blown into the vat has evidently nearly mastered the reducers present. It may be observed that no great amount of air is used or is necessary in the Brown vats.

Solutions in Extractor Boxes.

STRONG BOX.

Leaving Compartment.	Temp. C.	Free KCN.	Oxygen.	Au. dwt.	Extraction.
0	13	·039	5·5	6·25	...
1	...	...	1·5	5·48	12%
2	...	...	0·5	3·60	34%
3	...	...	Trace	1·10	69%
4	...	...	Trace	0·18	84%
5	...	...	Trace	0·04	78%
6, 7 empty	...	·037	0·5	...	...

SLIME BOX

Leaving Compartment.	Temp. C.	Free KCN	Oxygen.	Au. dwt.	Extraction.
0	19·5	·013	6·0	1·48	...
1	...		4·5	1·30	12%
2	...	...	0·5	0·85	35%
3	..	...	Trace	0·20	75%
4	...	...	Trace	0·04	81%
5	...	...	Trace	0·01	75%
6 and 7	19·5	·012	Trace	0·01	...

Strong box was taken third day after dressing and slime box eighth day. Though first compartment of strong box removes most of the oxygen, little gold is taken out, and the extraction is much improved when the oxygen is gone. The first compartment in slime box, choked with white precipitate, does little work on oxygen or gold. The third compartment, which shows no white precipitate on top, does excellent work, as is the case with the following ones.

These results lend no support to the theory that presence of oxygen assists precipitation of the gold by its depolarizing effect. Practically no bubbles are to be seen on slime boxes (except just after a dose of solid cyanide) so that the oxygen is not removed by mechanical effect, which would require at least 115 cu. in. of hydrogen per minute to merely displace the oxygen and nitrogen present, and not 1% of this quantity is given off in bubbles—which, in any case, are nearly pure hydrogen.

If we consider the fact that only those compartments of the slime boxes show white precipitate where oxygen is present and that strong boxes never produce it, further light is obtained on an unsolved problem.

The usual equations show that 6 mgm. oxygen per litre correspond with:—

0·019 lb. Zinc per ton of solution, or	0·0025%
0·195 lb. Cyanide of Potassium, or	0·0097
0·060 lb. Sodium Hydrate, or ...	0·003
0·012 lb. Oxygen, or	0·0006

(and 1·44 oz. gold per ton).

Moir has shown that zinc oxide is practically insoluble in alkali of our usual strengths, therefore 0·0097% of true free cyanide at least must be present to dissolve the zinc oxide produced as rapidly as it is formed from the oxygen present, and if less than this amount is present (which might correspond with anything from 0·013 to 0·038% of the free cyanide of the works test) white precipitate must be formed. If, however, sufficient true free cyanide (apart from that associated with zinc) is present, or if the oxygen is eliminated, no white precipitate will be formed.

This gives the correct line on which to work to free our plants from this objectionable product:

(1) We might add 0·16 lb. sodium cyanide at the head of each box for every ton of solution, but this would be too expensive, and, moreover, might lead to troubles in other directions.

(2) We might expose the solutions to high vacuum by means of receivers and vacuum pump as in ordinary steam practice.

(3) By known means we might remove oxygen from the air and bubble the nitrogen through the solutions which would be kept under nitrogen atmosphere till extractors were passed.

(4) Chemical means might be employed, such as the use of 0·08 lb. of sodium bisulphite per ton of solution.

The expense of any method, however, would have to be borne by the consequent saving of zinc, which would hardly amount to more than 0·1 lb. per ton of pulp, and even at present prices one penny per ton seems a poor figure to do much work for, though improvements in other directions would probably be simultaneously obtained.

Mr. Jas. Gray (*Member of Council*): I am sure we have all listened with great pleasure to Mr. White's interesting paper on the determination of oxygen in cyanide solutions. Personally, it is a subject I know little or nothing about. We must all admit it is a most ingenious adaptation of well-known principles to everyday work, and I am sure it will give quite a lot of food for thought among those who come into contact with this problem. Our old friend, white precipitate, comes again to the fore, and I hope those who were enthusiastic on the subject about fourteen years ago will come forward to support or confute Mr. White in his statements. I have very much pleasure in moving a vote of thanks to Mr. White for his paper.

Mr. J. E. Thomas (*Past-President*): In connection with the paper we have just heard read by Mr. White, I should like to remark that in 1909, when I was on the Simmer and Jack P.M., Ltd., we had two slime plants running. The solution from the one plant gravitated from the filter-beds to the extractor boxes, from the other it had to be pumped through a Gwynne centrifugal pump. The quantity of white precipitate formed in the boxes to which the solution was pumped was greatly in excess of that formed in those to which the solution gravitated. This, I always considered, was due to the fact that the Gwynne pump sucked air and so aerated the solution. Of course, I am not prepared to deny that some air may also have been drawn through the glands of the pump. The main feature is, however, that one may expect more white precipitate to be formed from an aerated solution than from one kept as free from air as possible. This is also borne out by the fact that warm solutions, containing naturally less oxygen than cold solutions, do not form white precipitate to the same extent.

Mr. H. Rusden (*Associate*): Mr. White's use of Pyrogallol reminds me of some experiments which I tried some years ago when the subject of the estimation of oxygen, in working cyanide solutions, was under discussion by this Society. The principle which I worked on is a well-known one, that pyro solution, on the addition of alkali, becomes a very rapid and complete absorbent of oxygen. A flask of known capacity was filled with the cyanide solution to be tested and fitted with a delivery tube filled with previously boiled water, thus excluding air. An inverted glass-cock burette filled with a portion of the caustic potash solution and supported over the extremity of the delivery tube ensured that all gases expelled on boiling the cyanide solution would enter the inverted burette. When it was observed that no more gas was being collected, the number of cc. was noted. By means of a short length of rubber tubing, a small burette containing 5 solution pyrogallic acid was connected to the top of the inverted burette, the stopcock was then opened and 5cc. of the Pyro. solution was drawn into the mixed gases and caustic potash solution. Absorption of the oxygen was very rapid, the burette reading was again taken, the difference between the original and last readings indicating the amount of oxygen present. I aimed at comparative, rather than accurate oxygen determinations, as the latter would involve several corrections. I admit that Mr. White's colorimetric method is far superior in every respect to the principle I worked on.

NOTES ON THE REMOVAL OF A VERTICAL SHAFT PILLAR.

By J. Chilton (Member of Council).

The Village Main Reef Gold Mine is situated in the Witwatersrand central area. To the north lie the exhausted claims of the Wemmer, Salisbury and Jubilee; while to the south are the extensive workings of the Village Deep. East and west are respectively the City and Suburban and Ferreira Deep Mines. Being thus surrounded on all sides by the workings of other mines, it was recognised that exceptional measures would be necessary for roof support, and 6 of the total mining area was left *in situ* in the form of stope and drive pillars. These supports, with the aid of large unpayable blocks, were, at the time, thought sufficient to meet any pressure that was likely to be met with in the course of mining operations. The main vertical shaft is sunk to a depth of 1,375 ft. At 1,200 ft. the South Reef crosses the shaft at an angle of 30°, and the Main Reef Leader is met with 60 ft. lower. To guard against any movement in the shaft, and to support the mill, engines and other valuable machinery, a large shaft pillar, 60,000 sq. ft. on the South Reef and 160,000 sq. ft. on the Main Reef Leader was left. Mining authorities differ widely in their estimates of the size of pillar that is necessary for shaft protection. The following table has been made, showing the divergent views of mining authorities on this question:—

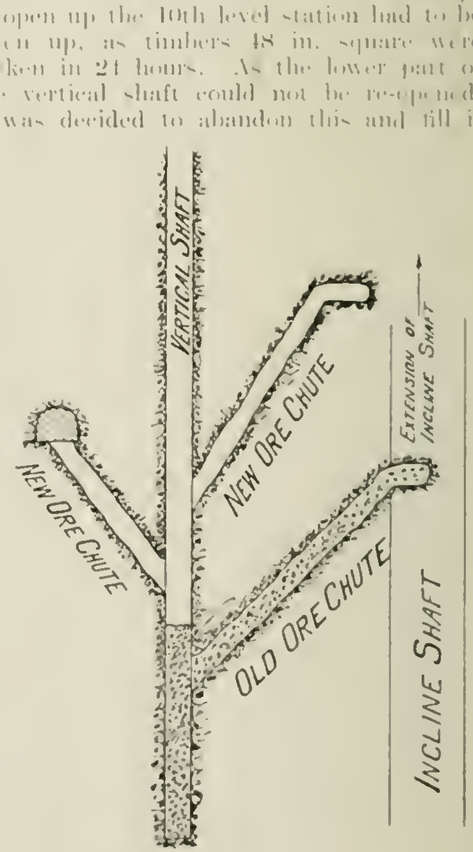
Authority.	Shaft Pillar: Depth of shaft 600 ft.	Shaft Pillar: Depth of shaft 1,500 ft.
Andre ...	135 ft. square.	315 ft. square
Foster .	360 ft. diameter	570 ft. diameter
Hughes ...	600 ft. ,,	1500 ft. ,,
Lapton ...	399 ft. ,,	999 ft. ,,
Merivale ...	93 ft. square	150 ft. square
Pamley ...	195 ft. ,,	420 ft. ,,
Wardle ...	180 ft. ,,	405 ft. ,,

The difference shown in this table is certainly remarkable: Hughes requiring in the latter case a shaft pillar that is almost eighty times as large as that desired by Merivale. If the sizes of shaft pillars here outlined were sufficient with the soft thill of a coal seam, it might reasonably be supposed that a much larger pillar standing on hard quartzites would be sufficient to resist either roof pressure or "draw," *i.e.*, that is the lateral disturbance beyond the point actually worked; yet in the year 1908 a vertical fissure in the south-east corner of the shaft appeared, indicating that some movement was taking place in the absolute roof of the mine. This crack extended up the shaft for about 300 ft., and gradually opened till it was 3 in. wide. It was then decided, on the advice of Mr. Stuart Martin, the Consulting Engineer of the Rand Mines, to carry out extensive sand-filling operations to strengthen and support the area round the shaft, and over half a million tons of sand were flushed into these workings.

Some time previous to this, slight earth tremors had been recorded on the surface, and shattering and scaling of pillars had been noticed in the drives and stopes north of the shaft, but nothing to cause alarm or uneasiness; and the main arteries of the mine were still regarded as absolutely secure. Round the shaft pillar there were no signs of creep or roof weighting, and timbers seemed to be under little strain. On the morning of November 10th, 1914, the shaft pillar collapsed during a shock that startled the town of Johannesburg, and was felt to a distance seven miles from the shaft. On examination it was found that the roof, sides and floor of all the excavations near the shaft had been ruptured. The timbers in the vertical shaft had been broken and the shaft thrown out of line. The pumps, pump chambers and sumps had been destroyed, and the stations and ore-bins completely wrecked. A fall of hanging wall had occurred in a neighbouring incline shaft reaching over 50 ft. above the shaft timbers. Unfortunately, this accident happened while the shift of native miners was being lowered, and five were killed and thirty injured. The floor, sides and roof in the disturbed area had been shattered, and drives and stations were completely filled with debris, the rails being forced up against the hanging. A white onsetter working at the signal bells affirms that he was thrown up against the roof of the station, a distance of over 6 ft. It appeared as if the whole weight of the overlying strata had been carried on outer edges of the shaft pillar and these had suddenly failed. Strange to say, some timbers standing in the drives showed no signs of roof pressure, and the sand-filled areas round the shaft were undisturbed. This collapse was partly due to the fact that the sand had been flushed into the stopes round the shaft some years after these had been worked. By that time the roof had sagged between its supports, and was, owing to the compressibility of the sand, only partially supported. That the sand-filled area did receive pressure is evident from the complete flattening of a 12 in. air pipe that had been left in the sand for ventilating purposes. Although the sand-filling did not entirely prevent the accident, there is no doubt that it minimised its effects. To get the fullest benefit from sand-filling it ought, however, to follow the stope faces as closely as practicable.

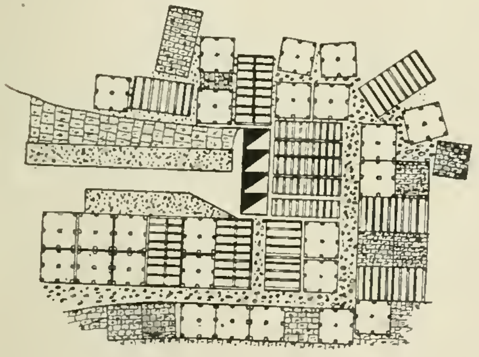
In a few months the mine was repaired and restored to its normal condition, and work resumed. Particular attention being directed to strengthening and supporting the sides of drives and stations with concrete pillars reinforced with wire ropes, cushions of sand were placed between the concrete and the country rock to distribute the pressure evenly.

On September 27th, 1915, the shaft pillar again collapsed; bad as the first accident was, it was completely dwarfed by this one. The vertical shaft was completely closed for over 200 ft., and stations and ore-bins were wrecked beyond repair. The concrete pillars were cracked and shattered, and fissures were visible in the shaft 300 ft. above the disturbed area. Unfortunately some native miners lost their lives in the mishap, and many were injured. For some time the situation was almost hopeless, and grave fears were expressed that the shaft would have to be abandoned. An attempt to open up the 10th level station had to be given up, as timbers 48 in. square were broken in 24 hours. As the lower part of the vertical shaft could not be re-opened, it was decided to abandon this and fill it



up with sand, and thoroughly reorganise the new shaft bottom. The incline shaft was lengthened; new ore bins were cut and new cross-cuts driven; the vertical shaft was straightened and retimbered, and after a stoppage of about five months, hoisting of rock was possible, and normal conditions again prevailed.

It may be contended that the shaft pillar in this instance was too small for the weight it was called upon to bear; but in mining it is always difficult to correctly ascertain the forces to be dealt with; and it matters not how large a pillar may be, if pressure accumulates beyond the elastic limit of the rock of which it is composed, it will certainly fail, often with a single burst of great severity. As reclaiming operations were taking place, necessitating the removal of pillars and small blocks of ground, a continual readjustment of pressure was taking place, and more and more weight was being transferred from pillars unto the solid blocks around the shaft. Shaft pillars that may be adequate in the early years of a mine, may become overloaded and fail as the excavations extend, and roof pressure increases.



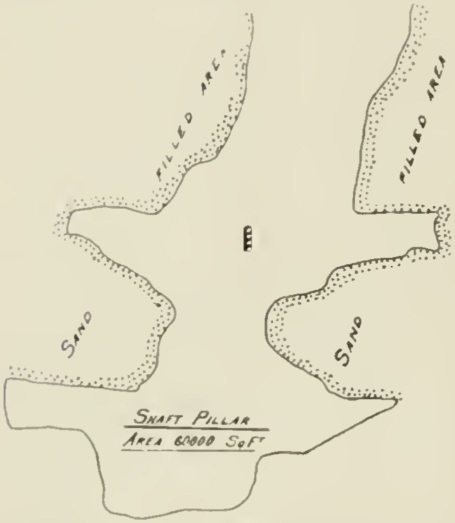
Plan showing arrangement of supports to replace Shaft Pillar.

As it seemed likely that further rock bursts might take place in this area, Mr. Stuart Martin, the consulting engineer of the property, decided that the somewhat heroic measure of removing the shaft pillar entirely should be attempted. As this shaft was the only one through which the ore could be hoisted, and its destruction meant the closing down of the property, it was realised that it was an operation demanding great judgment and skill, and that it was not lightly to be embarked upon. Probably only once before has a similar mining operation been attempted, and this was at the South Kirby Colliery, Nottingham, where, owing to creep round the shaft, it was decided to remove the shaft pillar. It was necessary to do this work in such a manner as to prevent any stoppage in the winding operations, and interfere as little as possible with the ordinary activities of the mine. The shaft consists of four compartments—two for hoisting rock and two for men and materials—and a start was made from the shaft timbers of the south compartment, or man cage way. A winze 6 ft. wide was driven from the shaft to connect with a raise coming up from a lower level, thus dividing the pillar and facilitating the handling of the broken ground, and forming a starting place for hand-stoping operations. From this winze an excavation about 20 ft. wide was made, completely encircling the shaft. As soon as a space of 6 ft. × 20 ft. had been excavated, a pigstye was placed in position. These supports were formed of blue-gum beams 12 in. × 12 in. in thickness and 16 ft. in length. These were framed together, so that when the pigstye was completed it measured 4 ft. in breadth and 16 ft. in length. Shorter lengths would have been easier to handle, but it was feared that the smaller pigstye might be crushed into the shaft if roof pressure became severe. A space of 12 in. was left between the shaft timbers and the supports. The pigstyes were carefully wedged and hand packed, the entire space being completely filled so that shrinkage could be reduced to the smallest possible amount. With the shaft as centre, the pigstyes radiated in all directions, and were put in as rapidly as the rock was excavated; at no time was a space greater than necessary left unsupported. The broken ore was passed down the winze to the level below, and as blasting only took place when winding was stopped, no interruption occurred, the holes being so placed as to blow the rock away from the shaft timbers. After the shaft had been encircled in this manner ordinary stoping operations were started, working outwards to the boundaries of the shaft pillar. The large pigstyes were only employed round the shaft, the remainder of the ground being supported by a new form of pigstye designed by Mr. H. C. Hilton. This new type has an open construction that permits of the building in of the filling material, thus

---

* "Removal of Shaft Pillar at South Kirby Colliery. C. Snow, T.I.M.E. Vol. XLVI."

increasing the resistance to pressure, and forming an almost solid support. Spaces between the pigsties were filled with waste rock until the whole area round the shaft was completely filled, with only spaces left going over an engine chamber and the stations. Filter mats were placed among the pigsties so that sand-filling operations could be undertaken, but owing to the flooding of the mine, this had to be put off till the dry season again comes round.



Some months have now elapsed since the shaft pillar was totally removed, and little movement has as yet been noticed. That some subsidence, probably not more than 2 in., has taken place is evident by the fracture of the main air column on two occasions; but an expansion joint will remedy this. The shaft timbers show no sign of movement, and no surface subsidence has occurred. The Main Reef Leader shaft pillar, which lies immediately below the South Reef pillar, is largely unpayable, so that there is no probability of its being removed, and no danger is anticipated from this source, as experience has shown that the large rock bursts do not occur when an excavation exists either above or below a block of ground, but if it were necessary to remove this other shaft pillar, it would be taken out in a similar manner. From the solid nature of the pillar which was observed during the course of removal, there is little room for doubting that if it had been allowed to remain, further rock bursts would most certainly have occurred.

Severe earth tremors are still being felt on the mine, and the most violent yet recorded at the Observatory, that of the 15th November, 1917, while damaging some of the lower levels, did not cause the slightest movement near the shaft.

In the light of the experience of the Village Main Reef and other neighbouring mines that have suffered in a similar manner, it seems probable that more attention might profitably be given to the subject of shaft pillars. The general tendency in European coal mines is to leave very large supports for the shaft, and in some of the deeper mines pillars having an area of over 130 acres have been left. In South African mines the size of the pillar is too often determined by the gold contents of the ore; a generous measure of protection being given where low grade rock surrounds the shaft; but with rich rock a much smaller support is deemed sufficient. In the new mines of the East Rand special precautions will have to be taken if creep and crush are to be avoided, as the soft slate footwall of our eastern mines is very similar to that found below the coal measures, and unless pillars are left of large area, the main arteries of the mines will certainly suffer from creep and crush even more than the central mines have done.

Some mining engineers have gone so far as to state that shaft pillars are neither necessary nor desirable, and that an excavation should be started from the shaft bottom, and extended outwards to the boundaries of the claim area, the space round the shaft being packed as tightly as possible with stone packing. In this way settlement would not be so great and would be more even, and the shaft would not be so liable to get out of plumb. Gob fires in coal mines due to crushing would also be avoided. Pickering, in his paper entitled, "Why Leave Shaft Pillars?", supports this view; but his idea was regarded as the freak of a crowded brain, and did not receive the attention the subject warranted. Mining engineers are notoriously conservative, and shaft sinking is costly, and they are few that would take the risk of losing a shaft for the sake of testing a theory.

I have to thank Mr. P. Cazalet for permission to publish these few notes.

Mr. E. M. Weston (*Member of Council*): I have very much pleasure in moving a vote of thanks to Mr. Chilton for his interesting paper. As we know, he has been connected with the Village Main Reef for a number of years. This has been a delicate and dangerous piece of work. As far as the safety of the mine and the people carrying out the work are concerned, this work has been very largely under his direction, as Underground Manager, and I think he is to be congratulated on having brought it to such a successful conclusion and on his promotion.

The question of shaft pillars is, of course, one that permits of endless discussion. The author refers to the question of shaft pillars on the East Rand. The decision, I think, as regards leaving shaft pillars depends very largely on the dip of the reef and the number of reefs to be extracted. On the East Rand we have one reef with generally a limited stoping width, lying rather flat, and the conditions of subsidence would no doubt be very different from where two reefs have been extracted on a dip of 60° to 40°, as on the Central Rand. So the problem is one, I should think, which would have to be solved for any particular mine.

Mr. H. S. Meyer: I beg to second the vote of thanks to Mr. Chilton for his paper, which is extremely interesting, and can really only be thoroughly appreciated by anyone who has been connected with the problem and seen the extraordinary conditions that had to be faced. I do not think the author—perhaps for fear of exaggeration—makes quite sufficient point about it. But I remember going down the mine on the second occasion, when the whole place closed in. It was simply an appalling sight. At first one imagined that the whole mine was gone, and the additional harrowing scene of dead bodies lying about all over the place was an occasion that anyone who was present would not forget in a lifetime.

I also think that a special word of congratulation should be given to Mr. Chilton, for, although he merely makes his paper a description of the work that was done, as Mr. Weston points out, he was very largely responsible for the completion of this dangerous undertaking.

The author in a general way discusses shaft pillars, and the authorities he quotes refer only to coal mining practice. I cannot agree that the local conditions in gold mining are analogous to any important degree. Indirectly, I think he views with the authority who boldly advocated the removal of shaft pillars and who was regarded, as he says, as one with a crowded brain. The shaft pillar question has locally been governed very much by circumstances; where the ore has been poor or unprofitable, large pillars have been the rule; on the contrary, when the ore has been rich, the pillars left have generally been inadequate when regarded as true shaft pillars. On the Far East Rand, where the strata has a very low dip, the pressure acts almost vertically, and the claim areas being relatively great the practice will no doubt be to leave very large pillars round the main shafts, although from a technical point of view I venture the opinion that there is no real need for such a policy. On the Central Rand in steeply inclined formation, the ground has a tendency to slide, and the weight of the overlying rock does not act entirely vertically. On this account the tendency to-day is to remove pillars and fill in the vacant spaces with sand, a method which enables the weight to be successfully controlled.

FERTILIZERS.

By Allan Baguley, B.Sc., F.I.C.

(Printed in Journal, November, 1917.)

REPLY TO DISCUSSION.

Mr. A. Baguley *(Member)*: Dr. Caldecott's desire for further details as to specific fertilizers mainly needed for staple crops and typical soils in this country, is not one that admits of full satisfaction in a limited space. Generally, the soils of the country are poor in phosphates. Maize is a staple crop which responds to applications of phosphates. Any fertilizer supplying phosphates is specific for maize. Phosphatic fertilizers would probably be effective in the following order:—

(1) Dissolved phosphates (including mineral super-phosphates and dissolved bones and guanos).

(2) Organic phosphates as fish refuse, whale meat, tankage and bone dust.

(3) Ground rock phosphates (the iron and aluminium salts).

(4) Bone meal (undissolved), and

(5) Ground rock phosphate (the calcium salt).

A mixture of the first three of these may very easily be more effective than any one of them, and, over a number of seasons, would nearly always be so.

The order of efficiency would be different in the case of another staple crop, lucerne, for instance, for which crop also phosphates are very necessary. Again, the potato is widely grown in South Africa in soils of a sandy nature. These are frequently notably deficient in potash, and, if a satisfactory crop is to be grown, potash must be supplied. By far the best method of doing this is by the addition of dung to the soil. Of potassium salts, the sulphate is the best. In this country muriate of potash and mixed salts, such as kainite and carnallite, should be avoided. These salts are unobtainable at the present time, and various kinds of ash appear the only sources of potash available. Ash in its crude condition should be used sparingly, or be put through a process to destroy its causticity. Even under the best conditions, potassium salts require care in application. On many soils of this country, lime may be regarded as a specific fertilizer for leguminous crops, as beans and lucerne. Other fertilizing substances are required as well. The lime is best used as ground limestone.

Experimental evidence that fats in fertilizers retard decomposition I find hard to obtain. A. D. Hall, in his book on "Fertilizers," says: "Oil hinders access of water and so delays the decomposition of the nitrogenous material. But considering how rapidly all oils and fats are attacked by bacteria, it is doubtful if this objection is valid, and actual experiments are lacking." In another place, under the heading of fish guanos, he writes: "This opinion—that the presence of oil delays the decomposition of such manures has really never been demonstrated." There can be no doubt that decomposition is more rapid in this country than in others with a colder climate. Mr. Warington Smyth complains of the difficulty of getting our farmers to use whale meat more than they do. The considerable prejudice, of which he speaks, is certainly less warranted in this warm country than in Britain or Holland. For all that, it cannot be contended that fats are of any use whatsoever in fertilizer, and a prejudice against their presence may be understood and forgiven, because, after all, it may be well founded. The question of the effect of fats on the decomposition of fertilizer is one that requires investigation in South Africa. Our agricultural schools and experimental farms might fairly be asked to afford us some experimental basis for their teaching on this matter.

Mr. White very truly says that, after all, the principal fertilizer is rain-water. Its superiority to stored water is, most likely, largely due to the fact of its containing more dissolved oxygen. This is a clear deduction from Russell's work on oxidation in soils at Rothamsted. Dam water is always, more or less, contaminated with dissolved salts and organic matter. The former are, more often than not, useless or harmful; the latter uses up the dissolved oxygen.

The effect of elementary sulphur applied to the soil as a fertilizer appears to me to be due to its influence on the microscopic soil flora and fauna. The sulphur may bring about partial sterilization of the soil, the benefits of which on crop production have been attributed by Russell and Hutchinson to the complete destruction of the larger soil organisms. In their absence the smaller organisms multiplied to an unusual extent with advantage to the crop plant. The elimination of amoeba and ciliata, which devour the bacteria and moulds, leads to the multiplication of these latter, which are useful organisms, active in the production of plant food. We hear from time to time of the good effects of ferrous sulphate, manganese dioxide and various other strange substances when applied as fertilizer. These effects are to be accounted for in the same way. What is required, is to determine which is the most satisfactory of such substances to use, or the best conditions under which one or other of them may be used. There are sundry proprietary soil disinfectants which benefit soils in a similar way.

Dr. Juritz, in a very instructive contribution, compares the relative utility of various mineral phosphates. In this connection an aspect of the matter, referred to by Professor Stanley in the case of potash compounds, should not be overlooked: that is the influence of the crop plant. Phosphoric oxide in any particular mineral may be available to one crop and not to another. Plants are not entirely dependent for phosphoric oxide on the disruptive effects of carbon dioxide, fermenting organic matter, fusion with sodium bi-sulphate and calcium carbonate, or solution in sulphuric acid. They each possess, in addition, powers of attack, proper to themselves and the determination of these is one of the important matters requiring investigation.

An obvious inference from Mr. Heslop's argument is that fertilizer is not the only requirement for successful agriculture. Others, rightly emphasised by him, are the need for guidance in choice of a district, so that the agriculturist may use his resources to the best advantage, and the need for drainage in alluvial flats where brak prevails. In many cases impossibilities are required of fertilizer. Mr. Heslop has pointed out that a generous application means only a very small percentage addition to the soil. There is, therefore, all the more reason for cutting out other causes of crop failure. Fertilizers will not bring about the benefits arising from, or obviate the need for, drainage, liming, dunging, irrigation and cultivation. After all, the areas of the country which do not benefit from fertilizers are only a small proportion of the whole, and it may fairly be said that, in the usual case, fertilizers afford at once the most general, the least expensive and the most effective means of increasing crop production.

The Chairman: I think you will agree with me that Mr. Baguley has added to the value of his paper by his very able reply.

A NEW METHOD OF DETERMINING COPPER.

By James Moir, M.A., D.Sc., F.I.C. *(Past-President).*

(Printed in Journal, November, 1917.)

REPLY TO DISCUSSION.

Dr. J. Moir *(Past-President):* Discussion on this paper having been rather like snakes in Ireland, my task in replying is easy; but I really think the time has come to change the Society's name to "The Gold Metallurgical and Mining Society!"

I am all the more obliged to my friend Mr. Watson for giving the method a trial. I think the explanation of any "trickiness" which he finds in the method lies in the absolute necessity of keeping down the acidity—which perhaps I did not sufficiently emphasize. It so happens that it requires very little acid indeed to cause thiosulphate to decompose, and of course if the decomposition goes so far as to liberate SO_2, the amount of iodine required to oxidize this to SO_4 is twice that which is required for the thiosulphate from which the SO_2 came—hence low copper results would be got. This is, however, quite avoidable by use of caustic soda before adding sodium acetate.

THE MANUFACTURE OF CRUDE SODIUM MANGANATE FOR USE ON THE MINES.

By F. Wartenweiler (Member of Council).

(Printed in Journal, January, 1918.)

DISCUSSION.

Mr. N. M. Galbreath *(Member):* I should like to congratulate Mr. Wartenweiler on his very interesting paper on the manufacture of sodium manganate. Regarding the formation of permanganate from manganate by dilution or by the addition of sulphuric acid, one atom of manganese is rendered useless for this purpose, either by the formation of MnO_2 or $MnSO_4$. The equation quoted by Mr. Wartenweiler shows this clearly:

$$3Na_2MnO_4 + 2H_2O = MnO_2 + 2NaMnO_4 + 4NaHO$$

This loss, which amounts to one-third of the manganese present in the manganate is a serious one. It is claimed for a German process that it removes this loss by effecting the conversion by chlorine gas, thus:—

$$2Na_2MnO_4 + Cl_2 = 2NaMnO_4 + 2NaCl.$$

The following is:

A Rough Method of determining the value of Manganate of Soda.—While engaged in manganate-making, about a year ago, I suggested the following rough method of analysis which I found handy and not too tedious. It is as follows: Weigh 10 grams of the roughly powdered manganate, transfer to a 500cc. graduated flask, add cold distilled water, shake until the soluble portion has dissolved, make up to bulk, mix, allow to settle, and pipette off 25cc. of the clear liquid, which represent 0·5 gm. of the material weighed. To this solution add a measured volume of N/10 oxalic acid (which is known to be in excess of the manganate present) 50cc. 10 H_2SO_4 and 25cc. distilled water, heat and shake until clear, dilute to 200cc. to 250cc. with hot distilled water and determine the amount of oxalic acid remaining, by titration with N/10 $KMnO_4$, observing the usual conditions as regards dilution, acidity and temperature. The difference between the amount of oxalic acid added and that remaining gives the amount oxidised by the manganate. The value may be reported in terms of oxygen; 1cc. N/10 oxalic acid = ·0008 gm. O. The method for the determination of MnO_2 given in Sutton's Volumetric Analysis, Manganese, 7, page 264, suggested the foregoing. Later on I found that a method, differing from the above only in details, was in use in chemical works. I have ventured to put this one forward as it may be of use to those who are not familiar with the subject.

The Chairman: We are glad to welcome Mr. G. [illegible] as a new contributor to our discussions.

THE ESTIMATION OF INJURIOUS DUST IN MINE AIR BY THE KOTZE KONIMETER.

By John Innes (Associate).

(*Printed in Journal, March, 1918.*)

DISCUSSION.

Mr. E. M. Weston (*Member of Council*): The excuse for an addition to my already too lengthy contribution to the discussion on this paper is the importance of this subject, and the fact that not having my copy of the report of the Miners' Phthisis Prevention Committee of 1916, I could not give quotations in support of what I maintained regarding the size of dangerous dust particles. I am also afraid that I may have unwittingly done the Committee the injustice of appearing to agree with Mr. Innes that they in any way had given him grounds for his amazing classification of dust into dangerous particles under 5 microns and all other dust of academic interest!!! As this report is not as well known or as widely read as it deserves, I may be forgiven for giving the following extracts:—

General Report, Chapter IV., page 20, Article 59: "These investigations are sufficient to indicate that it is the very fine particles which are the most important factor in the causation of the disease. It is therefore very probable that particles over *twelve microns* are relatively unimportant. The latter will throughout this report be referred to as *very fine dust*."

Appendix 6, page 83, by Drs. Watt, Irvine, Pratt Johnson and Steuart: "In all mine dust 85% by number of the particles are below 12 microns in diameter. It is the very finest particles only which enter the lungs. Dr. McCrae has shown that the great majority of the mineral particles found in the ash of the silicotic lung have an average diameter of less than one micron. Only a negligibly small number of particles were seen whose diameter exceeded 8·5 microns, and the largest observed was 10·5 microns." "It would appear therefore that the siliceous particles which are most important in producing silicosis are those of this minute size, 2·5 microns downwards."

Appendix 7, Dr. John McCrae: "The amount of material with diameter less than one micron was about 70% of the whole. . . . Many measurements were made of the particles constituting the remaining 30% of the material, the largest particles varied between 1 micron and 8·5 microns, the largest observed was 10·5 microns." Also see diagram on page 134 showing some of the "academic" particles over 5 microns in diameter.

Appendix 8: Dr. Watkins-Pitchford examined by polarized light 101 consecutive particles in sections of lungs showing double refraction. Of these Mr. Innes will be surprised to learn the dimensions fell in 30 instances between 4 and 6 microns, in 20 between 6 and 8, in 14 between 1 and 4, in 12 between 8 and 10, and in 6 between 10 and 13.

Appendix 9: Dr. Moir appears to have examined one lung of, I should say, a miner who had left underground work for a long period, and he found a very large proportion (93%) of the 120 particles examined to be under 2·5 microns in size; but he also found 1 in 2,000 over 8 microns diameter, and two particles, one 11 by 3½ microns and the other 13 × 3½ microns, and he estimated that they were about one in a million.

Regarding my contention that probably many of the larger particles are removed by Nature's methods after the miner leaves work and before his lungs become available for examination, I beg to direct attention to the last three paragraphs of Appendix 8 by Dr. Watkins Pitchford, which are too long to quote in full.

In view of the quotation, my contention that all mine dust (85% of which is below 12·5 microns in diameter) is dangerous is more than justified, and Mr. Innes's conclusions are founded on an entirely wrong assumption.

CEMENTATION PROCESS APPLIED TO MINING (FRANÇOIS SYSTEM).

By A. H. Krynauw (Member).

(Printed in Journal, May, 1918.)

DISCUSSION.

Mr. E. M. Weston *(Member of Council)*: This Society is to be congratulated on receiving the first account of the application of this process to mining on the Rand, and especially from one who has, like Mr. Krynauw, been actively engaged in the work. Regarding the explanation given as to the manner in which the cement fills the fissures and the pressure rises, this would seem to have great resemblance to the phenomena of deposition of ore in veins, and I think the explanation given is scarcely probable. I do not think even a pressure of 4,000 lb. per sq. in. would force water through solid cement filling fissures for scores or hundreds of feet. Is it not more likely that the cement is deposited first in the blind cracks and then in successive layers on the sides of the larger water courses, gradually reducing their free area and thus causing a rise in pressure while water still escapes, until the fissures fill completely by expansion? Cement expands 1 in 1,000 on setting.

Applications and limits of the Cementation Process.—The author mentions that pumping costs the Rand half a million. The cementation process cannot, I think, save any large proportion of this, for the simple reason that it can be economically used only where the exposure of the water-bearing fissures on the area excavated underground is a small one. A mine is of no value unless it has stopes, and it is obviously impossible to seal a fissure exposed for hundreds of feet in a stope. I am afraid Prof. Stanley is optimistic in cheering the Pretoria people with the suggestion that the water in the dolomite of the East Rand basin will be conserved *in situ* for them. This water has an awkward habit of descending into the stopes of the mines below through the numerous fault fissures and along the dyke walls that traverse the area. The service this process can render to shaft sinking has been and no doubt will be of immense importance.

There are few underground dams watertight, and in cases where the amount of leakage will justify the large expense, this process has undoubtedly a large field for application. The advantages and disadvantages of this method compared with the freezing method in shaft sinking would, no doubt, form the subject of an extensive treatise. Some data on this subject were recently published in the Abstracts of the Society's *Journal*. In cases where quicksands with much water were met with or in sinking through limestone or dolomite where extensive caves or fissures occur, the freezing process appears to offer advantages. One can scarcely expect to be told wherein the François system differs from others using cement in water fissures, nor wherein the patents of the process lie.

This matter may explain the absence of many practical details of the working of the process given in the paper. In the article on "Cementation on the Westonia field in West Australia," quoted by the Chairman, excellent details are given, and I hope the article will be published in the extracts. The author does not tell us whether he uses the diamond drill or the rock drill or both, or whether the diameter of the holes bored is varied or not. The type of hose or pipe and the connections used and the method of making them are matters of interest. The cost of the preliminary drilling in some cases shown seems a very large item. With regard to the Hatfield Main Colliery, the explanation given as to the use and effect of silicate of soda and sulphate of alumina may with profit be compared with the claims made as to their action by the patentee in Australia. It would seem that these solutions penetrated where an emulsion of cement would not, and, reacting, sealed the outer fissures.

The meeting then terminated.

Notices and Abstracts of Articles and Papers.

CHEMISTRY.

Pyrites in the United States.—"According to the U.S. Geological Survey never before was so much pyrites produced or imported by the United States as in 1916. The increase in production is to be attributed mainly to the greater yield from old mines rather than to the opening up of new deposits. The domestic production of pyrites in 1916 was 423,556 tons, which is about 30,000 tons more than in 1915. The consumption of pyrites—that is, the domestic production together with the imported ore—amounted to about 1,670,000 tons. In addition to the pyrites ore reported here, returns from acid manufactures show that 577,045 tons of domestic copper-bearing sulphide ores, 196,404 tons of foreign copper-bearing sulphide ores, 531,625 tons of domestic zinc sulphide ores, and 92,002 tons of foreign zinc sulphide ores were treated in 1916 for their sulphur as well as for their metallic content. The quantity of crude pyrites ore sold was about four times the amount of concentrates sold, the record showing that 336,000 tons of lump ore and 87,000 tons of concentrates were produced. The importation of pyritic ores showed a notable increase during 1916, and was the greatest in the history of the industry, being 1,244,662 tons."—*Indian Engineering*, Feb. 23, 1918, p. 107. (J. A. W.)

THE SPONTANEOUS FIRING OF COAL.—"Some further researches into the spontaneous firing of coal have been made in the last few years and the results are embodied in a paper read before the Institution of Mining Engineers by Dr. Haldane, Director of the Doncaster Coal Owners' Research Laboratory. They do not in any way upset the old fundamental theories but indicate a few practical measures which may be depended upon to prevent spontaneous combustion in individual cases. Heating up of stacked coal is no doubt the result of oxidation when the heat formed by the process cannot escape as rapidly as it is generated. Experiments at Cambridge have shown that when a small sample of suitable coal dust placed at ordinary temperature on the laboratory table was supplied with sufficient oxygen, and at the same time prevented from losing any heat, it burst into flame within about 24 hours. An important fact in connection with the behaviour of oxygen in the presence of coal has now only come to light, which is that coal takes up oxygen in two distinctly different ways. First, it combines with oxygen chemically, evolving much heat in the process. Second, it absorbs oxygen without combination and without heat, and this oxygen can be recovered from it by means of an air pump. Oxygen (also hydrogen and nitrogen) so absorbed by coal is much greater in quantity than such as goes into solution in an equal weight of water. The first process is the cause of spontaneous firing of coal, the second accounts for the presence of firedamp and other gases in coal. Another important fact is that the oxidation of freshly powdered coal diminishes with time. It is very rapid at first, diminishes greatly in a few hours, and continues to diminish until after a few weeks it becomes so small as to be hardly measurable. It is then incapable of any further heating unless the temperature of the coal is raised; and the surmise is that coal contains some particular kind of material attacked by oxygen at ordinary temperatures and also some other kinds which only begin to be oxidised when the temperature rises.

Now, coal when intact is a highly gas-tight material, hence a solid pillar or side cannot oxidise and heat because the oxygen cannot penetrate. Disintegration brought about by pressure, or otherwise, may, however, remove this immunity, as the oxygen can then get in and cause heating. In fact the rate at which coal combines with oxygen depends on its fineness of subdivision, and this explains why a lump of gassy coal gives off the firedamp contained in it very slowly, also the prolonged character of the oxidation process in coarse coal. Again, different coals contain varying amounts and varying qualities of what have been called the easily oxidisable materials, but all coals contain some. For instance, an examination of Welsh steam coals showed that the total quantity of material oxidised by air at temperatures up to 110° F. was so small that spontaneous firing could occur only in very exceptional circumstances, and hence coal from such seams never in practice gives rise to gob fires or spontaneous fires in cargo ships. In most of the other varieties of coal the total amount of oxidation increased rapidly with rise of temperature, and spontaneous firing would occur easily if loss of heat were prevented. As regards mines, in order that spontaneous firing may arise, there must first be coal inherently liable to it, then it must be finely broken in sufficient amount, there must be sufficient heat insulation and there must be sufficient oxygen. Excluding the first, all other conditions are more or less controllable, and the responsibility rests with the management to provide against them.

The main condition then to secure is a balance between heating and loss of heat, that is, air must pass through the coal in sufficient quantity to carry off all heat up to combustion point and there must be no insulation of heat. When a large mass of coal has to be dealt with the conditions to be faced are that air may be passing through it constantly in a certain direction; that the heat produced by oxidation in each layer will be carried onward to the next layer and so in each successive layer there will be a further rise of temperature till in time it will be sufficient to render the coal incandescent. In a small mass this accumulation of heat cannot occur, hence it is always safe against spontaneous firing whatever the quality of the coal; in a large mass, more particularly when there is also heat insulation, any kind of broken coal may fire spontaneously. Conditions underground are, as a rule, worse than above ground because artificial ventilation is apt to carry along a continuous slow current of air through a layer of broken coal, which, as before explained, may, in its progress, keep rising in temperature till combustion point is reached. Ordinary gob-fires seem to be always produced in this way. A layer of small coat and stone two or three feet deep, and with free air above it, will seldom heat appreciably, since the convection currents in the coal are in an upward and downward direction, so that any heat formed escapes rapidly to the air. But when the roof has settled down, and there are still conditions which cause a slow flow of air along the layer of small coal, cumulative heating will at once begin to tell. And it must be remembered that all the latent heat set free by the evaporation of moisture is also carried forward. In the case of a thick seam of coal or of a deep stack of coal on the surface it is possible for the up and down convection currents of air to accumulate heat in the same way. As regards oxidisation, it seems to have been proved that the total up to a temperature of 100° C. is limited, but there is an increase with increase of temperature, so that at 160° C. about 50 times as much oxygen is taken up as at 30° C.; and as regards the substances that oxidise, one at least is pyrites though there is a difference with different coals as to how much pyrites and what other substances as well oxidise. Powdered pyrites itself will fire very rapidly in an air current if loss of heat is prevented. The rate of oxidisation varies, not directly but, as about the square root of the oxygen percentage, so that in order to diminish the rate of oxygen to half it would be necessary to diminish the oxygen percentage to about a fourth. This means that spontaneous heating will go on even if the oxygen percentage is so far reduced that a man or animal would rapidly die in convulsions to the air

The practical lesson to be derived from these new facts is that all coals should be first chemically examined with regard to their tendency to spontaneous heating and the method of working based on such information. For instance, if a coal is liable to heating and also crushes easily it will be unsafe to work it with narrow pillars or ribs and advisable to protect supports against crushing; also where seams are thick it will be advisable to carry the main roads above or below the coal. Were all the coal, good or indifferent, removed from mines there could, of course, be no gob fires, but, although the time may come when this will be done, all that can be done at present is to make goaves as safe as possible when they contain coal. For this purpose the pressure of ventilating air should be kept low, which means the provision of roomy roads; and the goaves should be left as airtight as possible. Any disused road which might serve as a channel of access of air should be stowed tight, the roof should be allowed to settle down evenly behind an advancing face, with a minimum of breakage of any roof coal left, and to this end all props should be withdrawn. As regards stacks of coal it must be remembered that even though they have been left exposed for a long time without firing, it is quite possible for them to start firing should their temperature be afterwards raised from any cause." J. S. Haldane.—*Indian Engineering*, Dec. 22, 1917, p. 348. (J. A. W.)

Continuous Distillation of Coal Tar.—"According to the *Chemical Trade Journal*, a communication has been received by the British Patent Office from, and a patent granted to, Messrs. Sulzer Brothers, of Winterthur, for an invention relating to the continuous distillation of tar in two or more drums heated from the outside—the tar to be distilled passing through the drums in succession, while the heating gases are guided in the opposite direction along the drums on the counterflow principle. It has been proposed in similar apparatus to employ two stills, each with its own furnace, and to connect the furnace flues by a passage controlled by dampers; so that the gases from either furnace, after passing round the still belonging to that furnace, can be directed to, and flow round the other still before passing out to the air. In the construction according to this invention, however, the two distilling drums are set in the same block of masonry. The tar is admitted continuously through the coils of a preliminary heater into a drum, where the light oil and the ammonia liquor are evaporated and conveyed to condensing apparatus. The tar, deprived of its light oil and ammonia liquor, then flows into the second drum, in which the distillation is completed. This is more strongly heated, and situated at a lower level than the other drum. The pipe conveying the vapours from the second drum leads to another condensing apparatus; while the remaining pitch escapes continuously through a pipe close to the part of the drum which is most strongly heated."—*Indian Engineering*, Nov. 17, 1917, p. 275. (J. A. W.)

Coal Analysis.—"A new procedure is suggested for the analysis of coal in which the moisture, coke, and ash are estimated with the same weight of coal in the same apparatus—a bent, hard glass tube ('duck' shaped). For the estimation of moisture, the tube is connected to weighed calcium chloride tubes, the bend is immersed in a bath at 105 deg., and dry hydrogen is passed through. After removing the drying tubes, the coal is coked in the current of hydrogen, and finally burned in a stream of oxygen for the ash determination. As an alternative, the combustion tube may be sealed to a tube bent into two parallel U's, the second of which is filled with glass beads. With this, the dried coal is coked and the tar and water absorbed in the bent tubes, which are cooled. The coking tube is then severed, and so the weights of coke and of tar plus water, and consequently of gas, can be obtained."—*Indian Engineering*, Feb. 23, 1918., p. 107. (J. A. W.)

METALLURGY.

Ore Treatment at White Caps.—"The oxidised gold ore of the White Caps mine, at Manhattan, Nev., changed at 150 ft. to a refractory sulphide containing stibnite and realgar as well as iron and manganese. The new treatment plan is a carefully controlled roast followed by leaching with dilute, neutral cyanide solution. A 90% extraction is indicated at a total milling cost of $2 per ton.

The mining town of Manhattan, Nev., has recently come into prominence through the discovery of high-grade gold ore in the White Caps mine. Manhattan is 45 miles north of Tonopah, the nearest railroad point, and was one of the early southern Nevada 'boom camps.' The capital interested was chiefly from San Francisco, and when the 1906 disaster occurred, the Manhattan boom collapsed.

Oxidized gold ore outcropped on the White caps property and was followed by an inclined shaft to a vertical depth of 200 ft. The ore was treated in a local mill. At the 150 ft. depth, the water level was reached and the ore changed to a sulphide which was refractory to amalgamation or direct cyanide treatment. In 1912 a group of Tonopah men leased the property and erected a mill and cyanide plant of 75 ton daily capacity. By the time the lease expired, all the available oxidized ore had been worked out. Operations on company account were then resumed, and shipments were made of high-grade sulphide ore. However, as this was limited in quantity, and there was no method of treating the lower-grade sulphide ore, the mine was shut down. During this period a new, two-compartment vertical shaft was raised to the surface. Total production from these operations, exclusive of ore on dumps from recent development, was 19,909 tons, assaying $19.14 per ton in gold, and amounting to $381,053 in terms of gross value.

In June, 1915, the White Caps Mining Co. was incorporated and took over all of the assets of the old Dexter-White Caps Mining Co. The new company began active work on the White Caps property, and a process was developed for treating the sulphide ore. It was found that by roasting the ore within certain degrees of temperature the roasted product could be readily cyanided, and a good extraction obtained with a fairly low cyanide consumption.

In February, 1916, work was started sinking the vertical shaft to the 300 ft. level. By August of the same year the two main oreshoots had been cut on this level. Sinking was again resumed and the shaft sunk to the 425 ft. level on which the ore was cut in April, 1917. The ore occurs in a bed of limestone from 20 to 100 ft. thick, the limestone being cut by numerous faults into blocks up to 200 ft. long. Only two of these have been explored to date, and in them have been found the east and west oreshoots respectively. On the 125 ft. level the east oreshoots was 195 ft. long, with a maximum width of 40 ft., and the west oreshoot was 90 ft. long, with a maximum width of 18 ft. It is difficult accurately to estimate tonnage and grade, but the ore so far developed is expected to exceed $20 per ton. A new mill, recently completed, consists of a crushing and cyaniding plant with an estimated daily capacity of 150 tons, and a $22\frac{1}{2}$ ft. diameter, seven hearth, Wedge mechanical roasting furnace. Crude oil will be used as fuel for the roaster.

Early Futile Attempts to Treat Sulphide Ore.—The long delay in the development of the mine was due to the peculiar mineralogical composition of the deposit and consequent difficulty of treatment, rather than to any lack of ore. The form in which the gold occurs is not known. The 75 ton mill that was erected in 1912 was an all-sliming cyanide plant constructed by the Associated Milling Co. for treating the ores from the White Caps and other Manhattan properties. This mill was operated successfully for a year, during which time an average extraction of 92% was obtained. As already stated, the oxidized zone in these properties extended only to a depth of about 150 ft. When this point was reached, it was found that an extraction of over 50% could not be secured by the simple cyanide treatment, and consequently the mill was forced to suspend operations in June, 1913.

Then followed a period during which various efforts were made to discover some method of treating these base ores. Samples were sent to metallurgists and ore-testing companies, but the results of their tests were apparently unsatisfactory. Since the oxidized ore could be readily treated by cyanide the idea of a preliminary oxidizing roast was one of the first to be investigated. However, because of conditions which will be explained later, these roasting tests were failures. In June, 1915, I took over the control of the White Caps mine, and exhaustive experimental work was begun, which finally ended in a satisfactory solution of the problem.

Analysis of Low Grade White Caps Ore.

Chemical Analysis.

	Per cent
SiO_2	13·0
Al_2O_3	0·4
CaO	18·0
MgO	4·0
Fe	6·1
Mn	0·2
S	4·3
As	0·6
Sb	0·6
Au	$16.00

Mineralogical Analysis.

	Per cent
SiO_2	13·00
Al_2O_3	0·40
$CaCO_3$	32·15
$MgCO_3$	9·56
Fe_2O_3	3·98
FeS_2	7·07
MnO	0·32
As_2S_3	0·86
Sb_2S_3	0·84

The accompanying table gives a typical analysis of the low-grade ore. After many tests it was found that the stibnite carried a small amount of gold, usually ranging from a trace to $2 per ton. The realgar carried more low grade ore. Most of the gold apparently is associated with a fine-grained black mineral which has not been identified. Tests for tellurium or selenium gave negative results. We were, therefore, forced to resort to the 'cut-and-try' method of attacking the problem, until sufficient data could be collected to suggest a more scientific mode of procedure.

The first work was done on the raw ore, and the following results were obtained: Flotation tests with various oils, with and without preliminary sulphidizing gave negligible results; the sulphides could be readily floated, but the gold content of the concentrate was little higher than that of the tailing; gravity concentration gave similar results; amalgamation gave low extraction, with fouling of the mercury. The following cyanide tests gave unsatisfactory results: Simple cyanide treatment, with various amounts of cyanide, alkali and lead salts; the bromocyanide process; preliminary treatments with caustic soda, sodium sulphide, sodium thiosulphate, cuprous thiosulphate and sodium sulphite; the sodium-sulphide treatment of cyanide tailing; cyanide treatment of flotation tailing; and aluminium-caustic soda desulphurizing, followed by cyanide treatment.

Conclusions from the Tests.—From the above tests the following conclusions were drawn: (1) The gold is not in a free state, since it cannot be amalgamated nor dissolved by cyanide even after the arsenic and antimony sulphide are removed by flotation or by preliminary treatment with alkaline sulphide; (2) the gold is probably not associated with the sulphide, nor combined as a telluride, as both gravity concentration and flotation were unsuccessful; (3) it is possible that the gold is combined with the manganese, but there is not enough data at present to warrant any definite conclusion; (4) it is known that arsenic and antimony sulphides and manganese compounds are all, under some conditions, detrimental to cyanide treatment and also that roasting is the common method of handling these substances.

The calcines from an ordinary oxidizing roast at a temperature of 1,500° F. yielded less than 50% extraction to cyanide treatment. The calcines contained unoxidized antimony sulphide. Addition of lead acetate was of little benefit. Treatment with caustic soda and thorough water washing, followed by cyanide treatment, gave better results, but the process was not commercially feasible. Chlorination was not considered practicable, because of the limestone gangue.

Specimens of pure stibnite were then roasted, and the following conditions observed: The oxidation of the stibnite was slow below a temperature of 800° F., but at this point the oxidation became rapid, and fusion took place at 850° F. After fusion, complete oxidation did not take place during eight hours of continuous rabbling at a temperature of 1,600° F.

By careful temperature control, it was possible to oxidize the stibnite completely in six hours. This same procedure was followed with the ore, and good results were obtained by cyanide treatment of the calcines. Pure stibnite added to a duplicate of the above test lowered the extraction nearly 50%. However, a roast of six hours under Manhattan conditions would be expensive, and such accurate temperature control would be almost impossible.

It was found that stibnite was very slightly soluble in a pure dilute cyanide solution, but readily soluble in a caustic alkaline solution. Consequently, by keeping the temperature below 1050° F. (the decomposition point of calcium carbonate) the formation of caustic lime could be avoided and it would be possible to treat the ore with practically a neutral cyanide solution, which would not dissolve the antimony sulphide. The ore was, therefore, given a one-hour roast under the above conditions, and agitated in a neutral 2 lb. cyanide solution for one hour. An extraction of 90%, with a cyanide consumption of less than ½ lb. was the result.

Leaching tests were next tried on the same type of calcines, and it was found that practically the same extraction could be secured by leaching a four-mesh product for 15 hours. A series of tests, re-using the same solution after zinc precipitation, showed no fouling of the solution and no difficulties in precipitation. Due to the excess of calcium sulphate formed during the roast, the slime settles rapidly without the use of lime.

From roasting tests made on the ore by the Wedge Mechanical Furnace Co., it is estimated that the fuel oil consumption will be less than 4 gallons per ton. On this basis the total milling cost, including crushing, roasting and cyaniding, will be approximately $2 per ton. The extraction should be about 90%. I take this opportunity to acknowledge the valuable assistance rendered by D. B. Bradner, whose untiring work developed the data from which a solution of the metallurgical problem of the White Caps ore was possible."—J. G. Kirchen. *Engineering and Mining Journal*, Nov. 24, 1917., p. 905. (H. A. W.)

MINING.

Comparative Values of Rock Drills.—"In the selection of a hammer drill, the essential points to be considered are its drilling performance and its resistance to wear and tear. With regard to the the former, it is a mistake to attach undue importance to the consumption of air alone, which, in itself, signifies nothing. It is not unusual to hear of cases where, with a compressor of 20 cub. meter capacity, preference is given to a hammer drill which consumes 1 cub. meter per unit over one consuming 1¼ cub. meter, because the former is considered more in accordance with the capacity of the compressor.

On the other hand, to judge solely by the drilling speed is another error to be avoided, even if that speed be proportionate to the consumption of air. For instance, a hammer X has a drilling speed of 20 cm. per minute, and another hammer Y will drill at the rate of 27cm. for the same time. The conclusion generally drawn will be that Y is the better tool, because, to get a performance equal to that of X, it would suffice at first to drill at the rate of 25 cm. per minute; therefore at 27 cm. it is superior, and each cubic meter will give a performance 8% higher with Y than X.

This reasoning, though broader than the preceding, does not take into account all the factors that go to determine the actual comparative value of the hammers. Admitted that this speed may be maintained for the first three minutes, will it continue for the three following? Will not the respective positions of the two hammers be reversed? And how will they stand with regard to their respective working returns at the end of the first hour, day or shift? It may naturally be asked how such an irregularity in movement and performance can exist where the conditions are perfectly equal. The answer is simple namely, that the daily performance depends on the weight of the hammer and on the extent to which the vibrations and shock produced by the hammer affect the operator.

In drilling vertical (downward) holes the weight of the hammer is of no consequence, a heavy tool being an advantage, if anything; but in drilling on the level or at a certain angle, in which the weight of the hammer has to be supported wholly or partially by the miner, every additional pound is a handicap and spells a diminution in the worker's output.

Easy handling, in other words, the more or less complete freedom from vibration, is therefore of primary consideration, the reaction of the hammer being very tiring to a workman, even though he has been long accustomed to the use of such tools.

As a further illustration, take the case of three hammers, X, Y, Z: X, as already stated, drilling at the rate of 20 cm. a minute, weighs, say, 30 lb., and sets up fairly strong vibrations; whilst Y, doing 27 cm., will turn the scale at 32 lb. and produce very heavy vibrations. Z, which is a light hammer, weighing 26 lb., does only 25 cm. per minute at the start, and consumes, perhaps, 1½ cub. meters of air. It would therefore appear to be inferior to the other two; but throughout the day its initial rate of 25 cm. will not fall below 20 cm., whereas that of Y will be reduced to an average of 12 cm., and that of X to an average of 13 cm. at the most. Which hammer of the three is the most economical is apparent. Assuming 7 h.p. per cubic meter of air at 10 cm. per h.p. hour, X will have cost, in ten hours, 7 fr. for drilling 18 meters, which is equal to 9 c. per meter. With Y, the cost will be 8·75 fr. for 72 meters, or 12·15 c. per meter. With Z, 10·50 fr. for 120 meters, or 8¾ c. per meter.

In comparing X and Z, where the difference in cost is scarcely appreciable, it must not be forgotten that the linear drilling power of Z will be 50% higher than those of X. And, besides the ¼ c. per meter represents on 120 meters, a saving of 30 c. per day to be added to the saving in wages, which amounts to 34%, as the operator will be able to do one-third more work. Putting the wages at 6 fr. per day, then the saving will amount to 2·30 fr. per day—or, say, 60 fr. per month; so that with ten hammer drills there would be an advantage of 600 fr. per month, or over 7,000 fr. (£280) per annum.

Another important factor in deciding the economic value of a hammer is the yearly cost of repairs and the length of time it is out of use for that purpose. In this respect the figures will vary with the make of hammer. Suppose, for instance, X or Y each cost 100 fr. a year, and Z, of superior manufacture, only 20 fr. for the first year's use. This difference of 80 fr. is far from representing the total saving effected by the use of Z in preference to the others, for X or Y will also have had to lie idle for about five days, if not more, for repairs and new parts every month. If we assume that, following the same proportion as in the cost of repair, Z will be in hospital only one day per month, it will have done four days' extra work on that time. Now, a 7 fr. per day, X will have lost 35 fr. per month in idle time as against 10·50 fr. in the case of Z: a difference of about 25 fr. per month, or 300 fr. per year, in favour of the latter. Thus, taking all the items into account, the use of Z would save 380 fr. per year in comparison with X, and still more as compared with Y."—*Echo des Mines.*—*Colliery Guardian*, Nov. 2, 1917, p. 850. (E. M. W.)

DISPLACEMENT VATS. "The general principle of displacement vats for measuring the air-consumption of rock-drills is known to all mining men, but it takes a good deal of experimenting to construct them so that they will work properly. It is hoped that these few suggestions will be helpful.

The elements of the displacement vats are two closed vats connected with a pipe at the base and equipped with valves so that air may enter one while leaving the other. The air in the two vats is always separated by a piston of water, which flows back and forth from one vat to the other. The change in level of the water in one vat multiplied by the area of the vat is the volume of air that has flowed out.

It will occur at once to the reader that there are two possible ways of measuring the volume of air displaced. In the first method we place on one vat a gauge-glass that reaches from the top to the bottom. We can read the gauge-glass at the start and after a given elapsed time, say, a minute, read it again. From these readings we can compute the flow of air per minute. The main drawback to this method is that the vats must be perfectly regular from top to bottom, or else the volume must be calibrated in many places.

In the second method we place two small gauge-glasses on one vat, one at the top and one at the bottom, and find the volume between two marks on the glasses. If we take the time from the water to rise from the lower mark to the higher with a stop-watch, the volume flowing per minute can be calculated. With this type of meter, vats of any shape can be used.

The air entering the vats must do so at constant pressure. A reducing-valve is needed. I have tried many kinds and the most satisfactory one is comparatively inexpensive. It is made by the Westinghouse Air Brake Co. and is known as the S 4 locomotive governor. The price is $21. It should be fitted with a hand-wheel so that it may be regulated easily. It should be arranged as shown in Fig. 1 (*a*). (All references will be to Fig. 1, unless otherwise specified.) The control-pipe *b* should not be connected to a vat because the valve continuously exhausts air to the atmosphere. A lubricator *r* should be placed on the control air line feeding very thin oil to the valve.

The air, after passing the reducing-valve, must enter first one vat and then the other and when it is entering one it must be leaving the other. These operations require a four-way valve. The stock four-way valve can be made with four single valves *c* arranged as shown, with levers, so that they can all be thrown together. The valves are made by the Westinghouse Company and are known as 1-in. cut-out valves. They cost $1.50 each. In the pipe *d* connecting the vats at the bottom should be placed a quick-closing gate-valve *e*. It is necessary to measure the volume of but one vat. Glancing at Fig. 1., place a mark on the gauge-glass *f* and fill with water to that point through the pipe *g*. Close the gate-valve. Draw off water through the pipe *g*, carefully measuring it until it

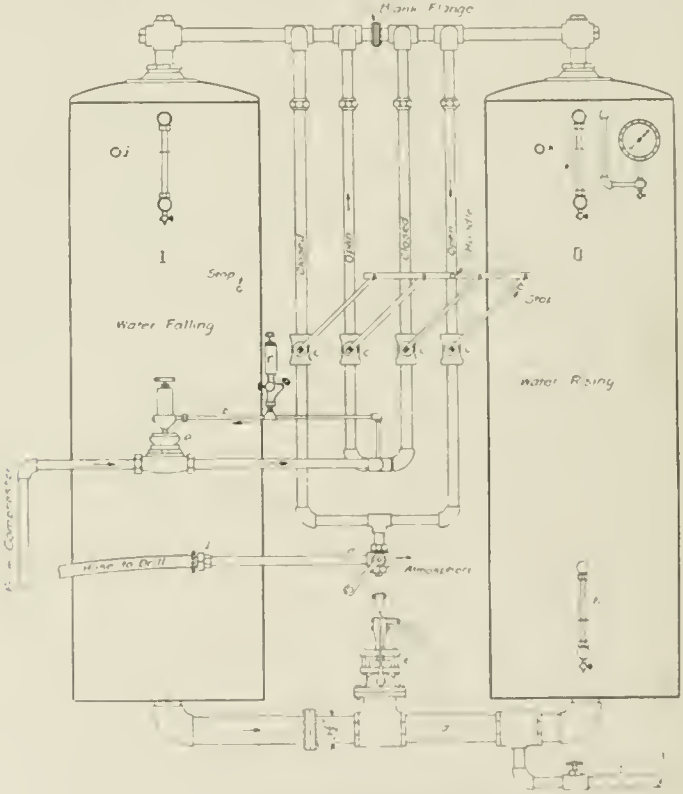


FIG. 1. Elevation of Meter

comes in sight on the glass *h*. Now draw carefully until an even number of cubic feet is reached and mark point on the glass *h*. When the water in vat II. rises from the lower mark to the higher, the measured volume of air has been displaced.

To obviate the necessity for watching the gauge-glasses I have arranged for a bell to ring at the two critical points. It is done by fitting up spark plugs so that a contact is made between the vat and the sparking point of the plug by means of a float. The principle is shown in Fig. 11. An ordinary automobile-plug fitted with a float is tapped in at *i*. A plug built as shown in the drawing is placed at *k*. The plug is so constructed that the point of ringing can be controlled by screwing the centre point in or out. The plug *k* is placed on a line with the mark on the gauge-glass. A water-glass should be placed opposite the plug *i*, as shown.

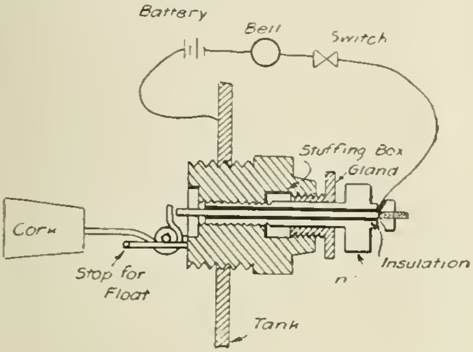


FIG. 11.—Contact Plug.

To put the apparatus in working order the water is run up in vat I. until the bell rings. The gate-valve is closed and the water in vat II. is brought to the lower mark. The gate-valve is then opened and the water is forced to the upper mark. The gate-valve is again closed and the spark-plug *k* adjusted by turning the nut *n* (Fig. 11.) until the bell rings at this point. Thus it is seen that between two ringings of the bell the measured volume of air has flowed out. The time is taken with a stop-watch.

To test a drill, connect the hose at 1 and start the drill running. Run water into vat I. until the bell rings. Throw the valves and while the water is falling to the level of the spark-plug *i* adjust the reducing-valve. Start the stop-watch when the bell stops ringing and stop it when the bell starts again by contact being made at *k*. To hold the pressure constant the reducing-valve must be changed slightly owing to the small change in hydraulic head on the air. A run of any duration may be made by throwing the valves at each ringing of the bell and keeping account of the number of throws.

The volume between marks on vat II. should be about 16 or 18 cub. ft. for ordinary drill-testing. Means should be provided to exhaust the air in the vats to the atmospheric pressure if necessary. In the vats shown in the drawing it is accomplished by a three-way valve at *m*. Charts may be plotted for different gauge-pressures with time in seconds between bells, against free air per minute." WALTER S. WEEKS.—*Mining and Scientific Press*, Dec. 15, 1917, p. 855. (H. R. A.)

MISCELLANEOUS

NITROGEN PRODUCTS AND COAL SUPPLIES.—An interesting statement has recently been made by the Ministry of Munitions with regard to the work done by the Nitrogen Products Committee of the Munitions Inventions Department. The questions which have been under investigation by that body have a far-reaching importance not only in respect to the production of explosives, but also in its relation to the future of agriculture in this country, and indeed throughout the world. Many will remember the alarming statements of that veteran chemist, Sir William Crookes, in 1898. He predicted a shortage in the world's wheat supply owing to a deficiency in fertilisers. At that time practically only two sources of nitrogenous fertilisers suitable for agricultural use was available viz., Chili saltpetre and ammonium sulphate. In 1913, the world's consumption of Chili nitrate was $2\frac{1}{2}$ million tons, and of ammonium sulphate about $1\frac{1}{2}$ million tons, and the requirements are increasing by 100% every decade. It is not surprising, therefore, that attention has been given to the possibility of increasing the supply from other sources. Sir William Crookes himself turned his attention to the problem of nitrogen fixation from the air; but, as the Ministry of Munitions reminds us, it was left to other countries to follow up his idea. In this country nothing was done beyond the recovery of ammonia as by-product of coal distillation at gas works, and at a relatively small number of coke ovens. To some extent this want of enterprise may perhaps be attributed to the prevalent belief that fixation of atmospheric nitrogen could only be commercially profitable where an abundance of cheap water-power was available, and it was in countries like Norway where the practical development of this idea was expected to be alone possible. Electric arc processes, such as those of Birkeland—Eyde and the calcium cyanamide process, accordingly were at first exploited in Norway but suffered from the enormous consumption of power involved. Thus the Birkeland-Eyde process consumed 28·3 kw. of energy per pound of nitrogen fixed, and even the more economical cyanamide consumed 11·0 kw.

In the meantime the German chemists were turning their attention to the discovery of a workable process of producing nitrates which would be independent of water power. Amongst these we may first mention the Ostwald method of oxidising ammonia by catalytic agencies. This process is particularly interesting because it is possibly applicable to the production of nitric acid from the ammonia produced in gas works and by-products coking plants.

The Nitrogen Products Committee has given close attention to the question of ammonia oxidation, and as a result several large chemical works in this country are using this method to take the place of the nitre pots used in the manufacture of sulphuric acid. These nitre pots consumed annually about 18,000 tons of Chili saltpetre, and in these times of tonnage scarcity the saving of this amount is an appreciable advantage. The cost of the Ostwald process is given as £2 10s. per ton of pure nitric acid, which includes 17s. 6d. for the cost of liberating ammonia from cyanamide an expense which would presumably be saved in the cases where the ammonia is directly produced from gas retorts or coke ovens. We have, however, still to learn whether this process will become commercially applicable in coke-oven practice.

A more promising procedure, invented by Prof. Haber, of Germany, is that of the synthesis of ammonia by the direct union of hydrogen and nitrogen at a high temperature and under very high pressures. It is said that by this means ammonium sulphate can be produced at a cost of £5 2s per ton, corresponding to about 3¼d per pound of nitrogen. Very little appears to be known in this country of the working details of the Haber process; but the Committee above mentioned have had it under close investigation, and a method has now been evolved which is said to have increased its efficiency far beyond anything hitherto attained in German practice. It is highly interesting to note that a semi-technical Haber unit is now in operation in this country, and we may expect that it will not be long before it is established on a commercial basis. The possibilities of the production of cyanamide are also under consideration, and there is every reason to believe that we are on the eve of important departures in the artificial production of nitrogen products in Great Britain.

All methods of nitrogen fixation, however, depend commercially upon cheap electric power, and the Committee is turning its attention to the possibility of reducing the cost of electricity from coal in addition to an increased recovery of ammonia and other by-products. It is known, for example, that ammonia is available as a leading product in the distillation of lignite, or in a Mond plant producing power gas from coal or peat. In America, the possibilities of the latter method have recently been examined by Dr. T. H. Norton, who advocates the establishment of an experimental Mond plant of 5,000 h.p., operating on waste coal, and others of lower capacity for dealing with lignite and peat respectively. There is reason to believe that where coal is cheap this will prove the most advantageous means for obtaining ammonia.

In the meantime it is worth recalling that the production of ammonia from various kinds of coal varies considerably with the temperature of distillation. According to experiments made a few years back by Oskar Simmersbach, the maximum yield of ammonia from Upper Silesian coal occurred at 900 degs. Cent., whilst with Westphalian coal it took place at 850 degs. Cent., and Saar coal required only 800 degs. Cent. It is, of course, known that concentrated ammonia dissociates at about 750 degs. Cent., but in a dilute state, as evolved in coal distillation, this decomposition exceeding 900 degs. Cent.

The whole question of nitrogen recovery from coal is assuming a prominent place in industrial chemistry of to-day. There can be no doubt that the question has been too long neglected, and one of the few benefits which the war has brought us is that we have been compelled to give our attention to it. Nor is it in this country alone that activity is being manifested in this direction. The whole question of the relationship of electro-chemical industries to coal supplies is being actively discussed in the United States, where the conditions are somewhat different from those in either Germany or Great Britain, owing to the fact that there are not only large coal supplies but also unlimited water power. It might, perhaps, be thought that the Niagara Falls would be selected, without hesitation, as the source of cheap power for these purposes. There is, in fact, already established there the Cyanamide Company of America, which is operating on a 27,000 h.p. scale. But there are divided opinions about the relative advantages of water power or steam plants for the production of electrical energy, and some engineers incline to the view that it would be better to erect large central stations near the coal fields, where it is believed that the cost of developing electricity would not be higher than $11 per horse-power year.

These questions, however, will eventually be solved by experience, as will also the problem of the best process to adopt in the production of nitrates. For the present it is enough to note that Great Britain is not again going to leave this matter to other countries to develop, and also that coal is certain to play an important part in its development."—*Colliery Guardian*, Dec. 7, 1917, p. 1087. (E. M. W.)

Abstracts of Patent Applications.

34/18. Harry Ward. An adjustable safety collar for cam shafts, tube-mill shafts, or the like. 22.1.18.

This application relates to an adjustable safety collar for cam shafts, tube-mill shafts and the like, and to the method of fastening collars for the prevention of lateral movement or swing in cam shafts and the like. It consists of an adaptation of the Blanton Key in combination with a saddle key, so as to secure sufficient grip on the shaft to withstand the vibration.

144/18. William Herbert Grinsted. Improvements relating to electric circuits linked by a relay or repeater. 4.3.18.

This invention relates to means for linking two electric circuits by means of an amplifier, relay or repeater adapted to transmit messages from one circuit to the other in either direction of working. Such circuits may be metallic or wireless. The system is particularly useful for linking two telephone circuits, but is not limited thereto, and may be applied to telegraphic or other circuits.

266/17. James Hamilton (1), James Henry Stathridge (2). Improvements in compressed air producing apparatus. 28.5.17.

This application refers to an apparatus consisting of a concentric injector to connect two or more gas or air receivers by which the volume of gas or air is increased.

Changes of Address

Members and Associates are requested to notify the Secretary immediately of any change in address, otherwise it is impossible to guarantee the delivery of Journals or Notices. The Secretary should be notified at once of non-receipt of Journals and Notices.

W. Anderson, *l/a* Transvaal & Delagoa Bay Collieries; P.O. Box 550, Johannesburg.
C. G. Brink, *l/a* Sheba; Fairview D.M. Ltd., P.O. Box 55, Barberton.
W. B. Cromley, *l/a* Day Dawn; Zinc Corporation, Broken Hill, New South Wales.
L. D. Hingle, *l/a* Crown Mines, Ltd.; Rand Mines, Ltd., P.O. Box 1056, Johannesburg.
W. Lee, *l/a* Master Cecil Mine; Bushtick Mine, near Bulawayo, Rhodesia.

INDEX.

INDEX TO VOL XVIII. 1917-1918.

(COMPILED BY THE SECRETARY, MR. FRED ROWLAND F.C.S.)

These portions in Italics refer to Original Notes and Papers read before the Society

A

PAGE

α benzildioxime, Reagent for Nickel. H. Grossman and J. Mannheim . 248
Abstracts, Chemistry 47, 89, 112, 141, 153, 163, 189, 223, 247, 279, 305
——, Metallurgy 48, 90, 115, 142, 157, 165, 191, 248, 280, 308
——, Mining 27, 50, 167, 192, 221, 281, 309
——, Miscellaneous 28, 51, 92, 144, 158, 169, 194, 227, 282, 311
—— of Patent Applications 54, 93, 118, 160, 196, 228, 252, 284 312
Accounts, Statement of 287
Acetylene, Explosibility of. G. A. Burrell and G. G. Oberfell . 51
Acids in Solution, Assaying . 221, 233
Adam, H. R.—on the Estimation of Injurious Dust in Mine Air 271
Addicks, L. Impurities in Electrolytic Copper Refining 158
Address, Changes of, 54, 94, 118, 146, 160, 172, 196, 228, 252, 284, 312
——, *Presidential. By G. Hildick Smith* 56
Air, Carbon Dioxide percentage in, Colorimetric Method for the determination of the, Higgins and Marriott ... 89
——, Dustiness, A study of the methods for determining. G. T. Palmer .. 9
——, *The Estimation of Injurious Dust in Mine, by the Kotzé Konimeter, J. Innes,* .. 199
Discussion 206, 211, 243 271, 304
——, Improvements in purifying. A. C. Whittome (Pat. Abs.) 284
——, Volatility of Gold in, W. Mostowitsch and W. Pletneff .. 113
Alcohol for Fuel .. 282
Alexander, Fraser on the Construction and Maintenance of Slime Dams 6
Alkali Dichromates and Chromic Acids, The Chemical Evaluation of. J. F. Sacher . . 113
Allen, A. W.—Tube Mill Practice
Alloys, New, to replace Platinum. F. A. Fahrenwald . 157
Aluminium from Clay . . 190
—— Dust .. 90
—— ——, Analysis of, J. E. Clennell 47
Amalgamation Plates, Gold Absorption by Copper, F. Wartenweiler 246
——, on Grease Plates 176
American Red Cross Mission to Palestine 229
Ammonia 223, 233
——, Direct Recovery of. 191
——, Improved Process and Apparatus for the Production of Recoverable, in the Manufacture of Producer Gas. Q. Moore and others (Pat. Abs.) 252
—— Leaching of Calumet Tailing, C. H. Benedict . .. 248
Ammonium Salts, Rapid Methods for Analysing Limestone and, Dr. James Moir. Reply to Discussion .. 62
Analysis, Chemical, Methylene Blue in, A. Monnier . 89
——, Coal. 307
—— of Molybdenum Ores. H. Westling and Carl Anderson 89
—— —— Pilgrims Rest Ore . 27
Anderson, C., and Westling, H. Analysis of Molybdenum Ores 89
Annual Report of Council ... 285
Antimony and Tin, Separation of, in Hydrochloric Acid Solution. A. Prim 223
Asbestos, Plantinized, Analysis of, V. N. Ivanov .. 90
Asclepias Fibre .. . 159
Ashcroft, E. A.—An Available Source of Potash . 217
Assay Economics. Chas. Toombs. 220
Discussion 233, 253
—— [illegible] John Watson 222
Discussion 233, 253
Assayers' Certificates 120
Assaying, Gold Bullion, Influence of Base Metals in, F. P. Dewey 161
Associates, New, 55, 119, 173, 197, 229, 290
Atomising Spray, Improvements in, H. C. W. Brown (Pat. Abs.) 252
Auditors, Election of Hon .. 290
Axles and Axle-bearings of Mine Trucks, Improvements in means for Lubricating, W. B. Jones (Pat. Abs.) 284

B

Babbitt Metal, Analysis of. E. W. Hagmaier 48
Bagley, T.—Fertilizers 121
Discussion 128, 149, 157
Reply to Discussion 301
Bain, H. Foster. Mining Problems on the Rand 167, 192
Balance, Limitations of the. B. Blount 172
—— Sheet, 1917-1918 287
Baraleff, D. The Colour of Magnesium Pyrophosphate 90
Barker, J. F.—Determination of Carbonates in Limestone and other Materials ... 279
Base Metals in Gold Bullion Assaying, Influence of. F. P. Dewey .. 161
Battery Shoes and Dies . 254
Bauxite, Fused, for Furnaces 280
Benedict, C. H.—Ammonia Leaching of Calumet Tailing . 248
Bicarbonates in Boiler Feed, Determination of Sodium and Calcium, H. Mohlhaupt 47
Bismuth and its Uses and Markets. B. Dunstan . 116
Blount, B.—Limitations of the Balance 172

PAGE

Boiler-Feed Determination of Sodium and Calcium Bicarbonates in, H. Monhaupt. ... 47
Borax ... 220, 233
Bottomley, F.—Fused Silica ... 154
Brazier, H.—on the Construction and Maintenance of Slime Dams. ... 67
Bricks, Silica, and some new uses for them. W. Gray. ... 92
Briggs, W.—Elements of Physical Science (*Review*) ... 27
Brines, Chemical Examination of Natural, O. R. Sweeney and J. R. Withrow ... 155
Browning, P. E.—Introduction to the Rarer Elements. (*Review*) ... 112
Buchanan, W.—Electric Steel-melting Plant ... 83
Discussion ... 85, 139, 186, 240
Bullion Assaying, Influence of Base Metals in Gold, F. P. Dewey ... 164
Burrell, G. A., and Oberfell, G. G.—Explosibility of Acetylene ... 51
Bushes for Battery Heads ... 255
Busveld, N.—A simple method for the determination of Calcium Oxide in the presence of Calcium Carbonate ... 279
Butter, G. M.—Handbook of Minerals. (*Review*) ... 46

C

Calcium Carbonate. A simple method for the determination of Calcium Oxide in the presence of, N. Busveld. 279
—— Chloride, Granular, as a Drying Agent, A. T. McPherson ... 156
—— Oxide, in the presence of Calcium Carbonate, a simple method for the determination of, N. Busveld 279
—— Phosphates in Citric Acid, Solubility of, A. A. Ramsay ... 155
—— and Sodium Bicarbonates in Boiler-Feed. Determination of, H. Monhaupt. ... 47
Calculator, Logarithmic, D. R. Robinson 60
Discussion ... 186
Reply to Discussion ... 219
Caldecott, W. A.—on Fertilizers ... 128
——, ——, *Mercury* ... 162
Discussion ... 173, 197, 232
Reply to Discussion ... 290
Callow, J. M.—Notes on Flotation 1916 ... 115
Calumet Tailing, Ammonia Leaching of, C. H. Benedict ... 248
Cam-shafts, an adjustable safety collar for, H. Ward (Pat. Abs.) ... 312
Canadian Mining Institute, Transactions of the, (*Review*) ... 88
Canvas for Amalgamating Plates ... 177
Capacities of Slime Thickening Vats, Determining of the, R. T. Mishler ... 115
Caramel, The Chemistry of, M. Cunningham and C. Doree ... 161
Carbis, W. J.—on the Estimation of Injurious Dust ... 214
Carbon Dioxide, percentage in Air, Colorimetric method for the determination of the, Higgins and Marriott ... 89
—— Monoxide Poisoning, Y. Henderson 92
Carbonates, Determination of, in Limestone and other materials, J. F. Barker 279
Carnallite and Sylvite, Iodine Content of Stassfurt, L. W. Winkler ... 113
Carson, H. Y., on American Red Cross Mission ... 229, 231
——, ——, on Estimation of Injurious Dust in Mine Air ... 246
Carter, Palmer, on the Estimation of Injurious Dust ... 213
——, ——, Systematic Packing Underground 24
Castings, Defective, Cement for ... 92
Cast-iron Pipe, Life of ... 283
Cavings and Movements ... 40
Cazalet, P.—Notes on the support of the Underground Workings of the Rand 2
Discussion ... 23, 39, 71, 103, 147
——, ——, on Systematic Packing Underground at the Ferreira Deep Mine 22, 24, 26
Cellulose and Chemical Industry, C. F. Cross ... 141
Cemalgamator and Separator, Improvements in, D Diver (Pat. Abs.) ... 196
Cement and Cement Pipes, Improved Moulding Machines and Moulds for Manufacturing, W. R. Hume 196
—— for Cupels ... 222, 233
—— —— Defective Castings ... 92
——, Effect of Sulphide on, ... 283
——, Grouting, method of cutting off a large water flow by means of, while sinking a mine shaft, A. François (Pat. Abs.) ... 94
Cementation Process Applied to Mining (François System). A. H. Krynauw ... 256
Discussion ... 265, 305
Changes of Addresses. 54, 94, 118, 146, 160, 172, 196, 228, 252, 284, 312
Charcoal Precipitation of Gold, H. G. Walton ... 191
Chatelier, H. le, and Bogitch, B.—Refractory Properties of Silica ... 156
Chemical Analysis, Methylene Blue in, A. Monnier ... 89
—— Abstracts 47, 89, 112, 141, 153, 163, 189, 223, 247, 279, 305
—— Industry, Cellulose and, C. F. Cross 141
Chemistry, Applied, Reports of the Progress of, (*Review*) ... 88
—— of Caramel, ... 164
Chicory Substitute from South Africa. ... 158
Chilton, J.—Notes on the Removal of a Vertical Shaft Pillar ... 297
Discussion ... 300
Choate, P. C.—Manufacture of Manganates 247
Chromic Acids and Alkali Dichromates. The Chemical evaluation of, J. F. Sacher ... 113
Chromium in Ferrochrome, The determination of, W. Herzig. ... 112
and Vanadium in Steel, Determination of, H. L. Hamner ... 190
Citric Acid, Solubility of Calcium Phosphates in, A. A. Ramsay ... 155
Clennell, J. E.—Analysis of Aluminium Dust 47
Coal Analysis ... 307
—— Distillation ... 189
——, The Spontaneous Firing of, J. S. Haldane ... 306
—— Supplies, Nitrogen Products and 311
—— Tar, Continuous distillation of, ... 307

PAGE

Coalfields, The Natal, Phases in Development. W. T. Heslop. Discussion 68
Reply to Discussion 184
Cobalt and Nickel in Ores and Alloys, Rapid method of determining, W. R. Schoeller and A. R. Powell 114, 164
—— its Uses .. . 143
Colorimetric Method for the determination of the Carbon Dioxide percentage in Air Higgins and Marriott 89
—— —— of determining Oxygen in Working Cyanide Solutions 293
Colouring, Metal. S Miyasawa 157
Colquhoun, L. on Assay Supplies. . 254
Compressed Air-producing Apparatus, Improvements in, J. Hamilton and J. H Stuthridge (Pat. Abs.) 312
Concentrate, Cyaniding Flotation, ... 167
Concentration of Ores. Improvements in, H. L. Sulman and E. Edser (Pat. Abs.) 228
Concrete Linings for Mine Shafts, etc Improvements in Reinforced, A. François (Pat Abs.) 94
Conklin, H. R.—New Method of Precipitating Gold from Cyanide Solutions by Zinc . 48
Contributions and Correspondence 27, 140, 162, 189, 245
Cooke, R. C. H—A Method for further Reducing Cyanide and Zinc Consumption. . . 33
Discussion 111, 185
Copper, A new method of Determining, James Moir 133
Discussion 135, 270
Reply to Discussion . .. 303
—— in Ores, Rapid Method for, E. Nyman 218
—— Refining, Electrolytic Impurities in. L. Addicks . 158
Correspondence and Contributions. 27, 140, 162, 189, 246
Cotton, Kafir or Natal . . 160
Council, Annual Report of. . 285
Craib, R.—The Furnace as an Adjunct to the Smithy on a Gold Mine . 251
Discussion 255, 291
Cross, C. F—Cellulose and Chemical Industry 141
Crosse, A. F.—Analysis of Pilgrims Rest Ore 27
Crucibles .. . 220, 222, 233
——, Melting in .. . 73
——, Palladium Gold, as Platinum Substitutes .. 154
Crushing Machines, Improvements in. E. B Symons (Pat Abs.) 196
Cunningham, M. and Doree, C The Chemistry of Caramel 161
Cupels and Cupel Powder 220, 222, 233, 253
Cyanide Dumps, Covering . 119
——, *Loss of, by Hydrolysis, James Moir* 189
—— Solutions, New Method of Precipitating Gold from, by Zinc H. R Conklin 48
—— ——, *Working, The Estimation of Oxygen in, H. A. White* 292
Discussion 296
Cyanide and Zinc Consumption, A method for further reducing, R. C. H. Cooke, ... 33
Discussion .. 111, 185
Cyanides, Improved Electrical Process for producing, Nitrogen Products Co. (Pat. Abs.) 252
Cyaniding Flotation Concentrate, J. G Parmelee 165

D

Desiccants, Some Common, A Comparison of the Efficiency of, M. V Dover and J. W. Marden 146
Dew, W. Elsdon, on Electric Steel Melting Plant 85
Dewey, F. J.—Influence of Base Metals in Gold Bullion Assaying .. . 164
——, Walter Process 90
Diaphragm Pumps, Application of, to Metallurgical Work. L. B. Eames. 95
Displacement Vats. W. S. Weeks . 310
Dixon, J. M—on Electric Furnace Manufacture of Shoes and Dies 240
Dolomite, The Alteration of, near Potgietersrust. R. B. Young ... 283
Door, Sliding, L. Janse (Pat. Abs.) ... 252
Dover, M. V., and Marden, J. W—A Comparison of the Efficiency of some common Desiccants. .. 146
Dowling, W. R.—on Report and Accounts . . 289
Draeger Mine Rescue Apparatus . 145
Drying Agent, Granular Calcium Chloride as a, A. T McPherson 156
Dumps, Covering Cyanide ... 119
Dunstan, B—Bismuth and its uses and markets 116
Durban Roodepoort Deep Mine, Mule Haulage Underground, at the, A. P. Rouillard 31
Discussion . 139
Dust Improvements in means of laying floating, J. L. Cruywagen (Pat. Abs.) 160
—— *in Mine Air, The Estimation of Injurious, by the Kotze Konimeter, John Innes* 199
Discussion . 206, 211, 213, 271, 304
—— —— Mines, Improvements in the treatment of, H. Belger (Pat. Abs.) 160
Dustiness, Air, A Study of the Methods for determining, G T. Palmer 92
Dwyka Conglomerate . 64

E

Eames, L. B.—The application of Diaphragm Pumps to Metallurgical Work 95
Election of New Members 55, 119, 173, 229, 290
Electric Arc Furnaces, Melting in 73
—— Circuits, Improvements relating to, linked by a relay or repeater, W H Grinstead (Pat. Abs.) 312
—— *Furnace Manufacture of Shoes and Dies on the Witwatersrand, G. H Stanley* . 72
Discussion 85, 139, 186, 240
Reply to Discussion . . 268

PAGE

Electric Induction Furnaces, Melting in. ... 73
Smelting of Titaniferous Iron Ores. A. Stansfield 141, 157
—— Steel. 144
—— —— *Melting Plant. W. Buchanan* 83
Discussion 85, 139, 186, 240
Electrolytic Copper Refining, Impurities in. L. Addicks 158
—— Zinc. 143
Explosibility of Acetylene. G. A. Burrell and G. G. Oberfell 51
Explosion of Fire Damp and Occurrences of Gob fires in Natal, J. E. Vaughan and F. A. Steart. Discussion 101
Reply to Discussion ... 216

F

Fahrenwald, F. A.—New Alloys to replace Platinum 157
Feeder Chute, Trommel 180
Ferreira Deep Mine, Systematic Packing underground at the. G. Hildick Smith and Paul Selby 9
Discussion ... 22, 39, 71, 103, 147
Ferrochrome, Chromium in. The determination of. W. Herzig. ... 112
Fertilizers, A. Baguley 121
Discussion 128, 149, 187
Reply to Discussion 301
——, Mineral 170
——, Solubility of Phosphoric Oxide in mixed. E. V. Flack ... 163
Fibres from Various Sources 159
Filters, Improvements in Outlet or Extraction Pipes of. J. J. Lassen and V. F. Hjort (Pat. Abs.) 51
Fire Damp, Explosions of, and Occurrences of Gob Fires in Natal, J. E. Vaughan and F. A. Steart. Discussion 101
Reply to Discussion ... 216
Firing of Coal. The spontaneous. J. S. Haldane 306
Flack. E. V. Some factors influencing the solubility of Phosphoric Oxide in Mixed Fertilisers ... 163
Fleuss Mine Rescue Apparatus . 145
Flotation Concentrate, Cyaniding. J. G. Parmelee 165
——, Differential, ... 247
——, Grinding Ore for, T. H. Rickard 280
——, Notes on, J. M. Callow 115
Fluid Pressure relieving devices, Improvements in (Pat. Abs.) 228
François System, Cementation Process applied to Mining. A. H. Krynauw . 256
Discussion . 265, 305
Fuel, Alcohol for 282
Furcroea fibre, ... 159
Furnace as an Adjunct to the Smithy on a Gold Mine, R. Craib... ... 254
Discussion .. . 255, 291
——, Fused Bauxite for. 280
——, Smelting, Improvements in. J. Tylor and Sons and others. (Pat. Abs.) 252

G

PAGE

Galbreath, N. M.—on the Manufacture of Crude Sodium Manganate 303
Galvanised Iron, Testing of. J. C. Witt 153
Gas Producers, Improvements in the working of, (Pat. Abs.) 228
German War-time Expedients 189
Gibbs' Mine Rescue Apparatus 145
Gifford, H. J.—on Covering Cyanide Dumps 119
Gob Fires in Natal, Occurrences of, Explosions of Fire Damp and, J. E. Vaughan and F. A. Steart. Discussion 101
Reply to Discussion 216
Gold Absorption by Copper Amalgomation Plates. F. Wartenweiler ... 246
—— Bullion Assaying, Influence of Base Metals in, F. P. Dewey ... 164
——, Charcoal Precipitation of, H. G. Walton 191
——, Precipitating, from Cyanide Solutions by Zinc. New Method of H. R. Conklin. 48
——, ——, Improved method for, A. Gordon (Pat. Abs.) 54
—— and Silver from Cyanide Solutions, Process and Apparatus for Precipitating and Recovering. K. B. Moore and H. R. Edmands (Pat. Abs.) 160
——, Volatility of, in Air and other gases. W. Mostowitsch and W. Pletneff ... 113
Graham-Rogers plate, The 92
Gray, Jas.—on Assayers' Certificates .. 121
——, on the Estimation of Injurious Dust in Mine Air 243
——, on the Estimation of Oxygen in Working Cyanide Solutions 295
——, W.—Silica Bricks and some new uses for them 92
Grease-plates, Amalgamation by 176
Greathead, C. H.—Further Notes on Sand filling of Mines 236
Discussion 240
Griffith, W.—Resistance of Artificial Mine Roof Supports. 226
Grinding Mill and tumbling comminuting bodies therefor. R. C. Newhouse (Pat. Abs.) 91
Grossmann, H., and Mannheim, J.—α-Benzildioxime (Reagent for Nickel) .. 248
Gum, South African, ... 159
Gyzander, C. R.—Notes in regard to titration of Sulphuric Acid.... 89

H

Hagmaier, E. W.—Analysis of Babbitt Metal 48
Haldane, J. S.—The Spontaneous Firing of Coal 306
Hamilton, W. Laurie (Obituary) 153
Hamner, H. L.—Determination of Chromium and Vanadium in Steel 190
Hardness of Metals, Tests for ... 146
Haulage, Mule, underground at the Durban Roodepoort Deep, L. P. Rouillard 31
Discussion 139
Healey, J. E.—on Systematic Packing Underground 24

PAGE

Heise, G. W., and Clemente, A.—Detinning and Analysis of Tin Plate 153
Henderson, Y.—Carbon-Monoxide Poisoning 92
Herzig, W.—The determination of Chromium in Ferrochrome 112
Heslop, W. Taylor, on Explosions of Fire Damp 104
—, —, on Fertilizers 187
—, —, *The Natal Coalfields. Phases in Development.*
Discussion 61
Reply to Discussion 184
Hibiscus fibre ... 159
Higgins and Marriott. Colorimetric Method for the determination of the Carbon dioxide percentage in air 89
Holloway, G. T. (Obituary) 152
Honours for Members. .. 197
Hoyt, W. E.—Practical Wood Preservation .. 281
Hutchin, H. W.—Determination of Tungsten 223
—, —, Wet Assay of Tin Concentrate. .. 18
Hutchinson, R. W.—Advanced Text Book of Magnetism and Electricity (*Review*) 88
Hybinette Nickel Process, The. 118

I

Indicator, Soap as an, in Volumetric Analysis. J. F. Sacher .. 113
Industrial Resources of South Africa. H. W. Smyth. 28
Ingle, F. C. W.—on the Estimation of Injurious Dust 213
Inglis, A. B.—on the Electric Furnace Manufacture of Shoes and Dies ... 244
Innes, John.—The Estimation of Injurious Dust in Mine Air by the Kotzé Konimeter. .. 199
Discussion ... 206, 211, 243, 271, 304
Iodine Content of Stassfurt Sylvite and Carnallite. L. W. Winkler 413
Iron, Galvanised, Testing of. J. C. Witt 153
Ore Supplies, German 284
Ores, Titaniferous, Electric Smelting of. A. Stansfield .. 144, 157
—, Smelting of Titaniferous Ores of. A. Stansfield and W. A. Wissler 50
Irvine, L. G.—on the Estimation of Injurious Dust in Mine Air 207
Ivanov, V. N.—New Method of Precipitating Platinum Sulphide and Analysis of Platinized Asbestos. .. 90

J

Jane, W. H.—on Electric Furnace Manufacture of Shoes and Dies 186
—, —, on Mercury 179
Johnson, F. H.—Separation of Fine Ore before Milling. 180
Johnson, J. Pratt—Silicosis in Rats in a Witwatersrand Mine. Discussion 135, 211
Reply to Discussion 209
Johnston, J. McI.—Conversion of Insoluble Phosphates. 140
—, —, on Mercury 175
—, —, on the Estimation of Injurious Dust 211
—, —, on an Underground Spring, containing Manganese, etc. 183
Juritz, C. F.—on Fertilizers 149
Jute 159

PAGE

K

Kapok 159
King, A.—on the Construction and Maintenance of Slime Dams. .. 66
—, —, on a method for further reducing Cyanide and Zinc Consumption .. 185
—, —, on Treatment of Pilgrims Rest Ore 36
Kirchen, J. G.—Ore Treatment at White Caps 307
Kirkland, J. W.—on Electric Steel-melting Plant .. 87
Komata Lining 49
Konimeter, Kotzé. The Estimation of Injurious Dust in Mine Air by the. J. Innes .. 199
Discussion 206, 211, 243, 271, 304
Kotzé, R. N.—on Systematic Packing Underground. 23, 26
Kotzé, Sir Robert, Congratulations to 285
Kruss Method of Gold Purification .. 113
Krynauw, I. H.—Cementation Process Applied to Mining (Francois System) 256
Discussion 265, 305

L

Laschinger, E. J.—on the Furnace as an Adjunct to the Smithy on a Gold Mine .. 255
Lee, R. E.—Phosphor Tin 164
Leslie, C. D.—on Systematic Packing Underground .. 21
Letts, E. A. and Rea, F. W.—Modification of Pelouze's method for estimating Nitrates .. 279
Limestone and Ammonium Salts, Rapid Methods for Analysing. Dr. James Moir. Reply to Discussion 12
—, Determination of Carbonates in. J. F. Barker 279
Lindsay, Robert.—Notes on Treatment of Pilgrims Rest Ore. Discussion 27, 36, 64
Reply to Discussion .. 99
Liners, Tests on Types of. 19
Liquids from Solids, Improved process of separating. A. M. Nicholas (Pat. Abs.) 51
Litharge. 220, 222, 233
Lithium and Manganese, Notes on an Underground Spring of Water containing. John Watson 181
Discussion 183
Logarithmic Calculator. D. R. Robinson 60
Discussion 186
Reply to Discussion 219

M

Macaulay, D.—on the Estimation of Injurious Dust in Mine Air 208
Macer, L. W.—on Treatment of Pilgrims Rest Ore 37
Magnesium Pyrophosphate. The Colour of. D. Baraleft. 90
Magnetism and Electricity, Advanced Text Book of. R. W. Hutchinson (*Review*) 88

Page

Manganate, Crude Sodium, The Manufacture of, for use on the Mines. F. Wartenweiler ... 161
  Discussion ... 183, 212, 303
Manganates, Manufacture of. P. C. Choate 247
Manganese and Lithium, Notes on an Underground Spring of Water containing. John Watson. ... 181
  Discussion ... 183
Manketti Nuts from S.W. Africa. 279
Mar, A Del.—Tube-milling (*Review*) 93
Marden, J. W., and Dover, M. V.—A Comparison of the Efficiency of some common Desiccants. ... 146
Marquard, J. D. on Support of Underground Workings and Systematic Packing ... 39
Marriott and Higgins. Colorimetric Method for the determination of the Carbon Dioxide percentage in Air... 89
Maxwell, F. A. G.—on Mercury ... 232
McPherson, A. T.—Granular Calcium Chloride as a Drying Agent. 156
Measurement, Stope, at the Messina Mine. W. Whyte ... 50
Meiklejohn, C. A.—on Assay Supplies. ... 235
Melkbosch. ... 159
Members, Election of. 55, 119, 173, 229, 290
Mercury. W. A. Caldecott ... 162
  Discussion ... 173, 197, 232
  Reply to Discussion ... 290
——, Chief Losses of ... 179
Messina Mine, Stope measurement at the. W. Whyte. ... 56
Metal Colouring. S. Miyasawa. 157
—— Mines, Mechanical Ventilation of. G. Rice ... 224
Metals from liquid matters, Improvements in apparatus for separating and detaining. W. G. Gibson (Pat. Abs.) 54
——, Substitute ... 190
——, Tests for Hardness of. ... 146
Metallic Sulphides, Improved process for the production of. C. O. Griffith (Pat. Abs.) ... 160
Metallurgical Abstracts. 48, 90, 115, 142, 157, 165, 191, 248, 280, 307
—— *Work, The Application of Diaphragm Pumps to. L. B. Eames.* ... 95
Methylene Blue in Chemical Analysis. A. Monnier. ... 89
Meyer, E. C. J.—on Estimation of Injurious Dust in Mine Air. ... 245
——, ——, on Sandfilling of Mines... 240
——, ——, on Systematic Packing Underground ... 21
——, H. S.—on Cementation Process ... 265
——, ——, on Election as President ... 290
——, ——, on the Removal of a Vertical Shaft Pillar. ... 301
Milligan, W.—Value and Importance of Physical Exercises. ... 227
Milling, Separation of Fine Ore before. 180
Mine Rescue Apparatus, Use and Testing of Oxygen, ... 144
—— Roof Supports, Resistance of Artificial. W. Griffith. ... 226
—— Shaft, Method for Sinking a, in a water-bearing soil. A. François (Pat. Abs.) 94
Minerals, Handbook of. G. M Butter (*Review*) ... 16
Mines of the Rand, Notes on the Support of the Underground Workings of the. P. Cazalet, ... 2
  Discussion 23, 39, 71, 103, 147
——, Research Work on. ... 56
——, *Sandfilling of, Further Notes on. C. H. Greathead.* ... 236
  Discussion ... 240
——, Witwatersrand, Ventilation on. 27
Mining Abstracts. 27, 50, 167, 192, 224, 281, 309
——, *Cementation Process (François System) applied to. A. H. Krynauw* ... 256
  Discussion ... 265, 305
—— Problems on the Rand. H. Foster Bain. ... 167, 192
Miscellaneous Abstracts. 28, 51, 92, 114, 158, 169, 194, 227, 282, 311
Mishler, R. T.—Determining of the Capacities of Slime Thickening Vats ... 115
Miyasawa, S.—Metal Colouring. ... 157
Moir, James.—Loss of Cyanide by Hydrolysis 189
——, ——, *New Applications of Thymolphthalein, and Naptholphthalein, including Rapid Methods for Analysing Limestone and Ammonium Salts.*
  Reply to Discussion ... 62
——, ——, *A New Method of Determining Copper.* ... 133
  Discussion ... 135, 270
  Reply to Discussion ... 303
Molybdenum Ores, Analysis of. H. Westling and Carl Anderson. ... 89
Monhaupt, H.—Determination of Sodium and Calcium Bicarbonates in Boiler-Feed 47
Monnier, A.—Methylene Blue in Chemical Analysis. ... 89
Morgan, G. T.—Utilisation of Nitre Cake. ... 47
Mostowitsch, W., and Pletneff, D.—Volatility of Gold in Air and other Gases ... 113
Muffles. ... 221, 222, 233
Mule Haulage Underground at the Durban Roodepoort Deep, Ltd. A. P. Rouillard. ... 31
  Discussion ... 139
Murdoch J. Microscopical Determination of the Opaque Minerals (*Review*) ... 87

N

Naphtholphthalein and Thymolphthalein, New Applications of, Dr. James Moir. Reply to Discussion ... 62
Natal Coalfields—Phases in Development. W. T. Heslop. Discussion ... 64
  Reply to Discussion ... 184
Nettle fibre ... 159
Newton, S.—on Construction and Maintenance of Slime Dams. ... 65, 185
——, ——, on Mercury. ... 178
——, ——, Returning thanks for Scrutineers 290
Nickel and Cobalt in Ores and Alloys, A Rapid method for Estimating. W. R. Schoeller and A. P. Powell 114, 164
—— Process, The Hybinette. ... 118
—— in Presence of Zinc and Iron, Determination of. S. Rothschild .. 48
——, Reagent for. ... 248

PAGE
Nipissing, Sodium Sulphide Precipitation at, R. B. Watson 142
Nitrates, Modification of Pelouze's method for estimating. E. A. Letts and F. W. Rea 279
Nitre Cake, Utilisation of. G. T. Morgan 47
Nitric Acid 221, 233 251
—, Possible Adulteration of. J. R. Withrow. .. 157
Nitrogen Products and Coal Supplies. 311
Notices and Abstracts of Articles and Papers, 27, 47, 89, 112, 141, 153, 163, 189, 223, 247, 279. 305
Nuts, Manketti, from S.W. Africa. 279
Nyman, E.—Rapid Method for Copper in Ores .. 248

O

Obituary :—
Holloway, G. T. 152
Hamilton, W. Laurie .. 153
Officers and Council for 1918-1919 290
O'Hara, J. D.—on the Construction and Maintenance of Slime Dams 138
Oil, Burning, from Worthless Tar . 189
—, Solvents for, ... 166
Ontario Nickel Commission's Report. . 118
Opaque Minerals, Microscopical Determination of the, J. Murdoch (*Review*) . 87
Open Hearth Gas Fired Furnaces, Melting in. 73
Ore Concentration, Improvements in, R. B. Martin (Pat. Abs.) . 54
— for Flotation, Grinding, T. H. Rickard. . 280
—, *Pilgrims Rest, Notes on the Treatment of, Robert Lindsay Discussion* . 27, 36, 63
Reply to Discussion 99
— Reclamation of, .. 15
—, Separation of Fine, before Milling 180
— Treatment at White Caps. J. G. Kirchen . . 307
Ores and Alloys. A rapid method for estimating Nickel and Cobalt in. W. R. Schoeller and A. P. Powell. .. 161
—, Finely divided, Process of and apparatus separating valuable particles of. H. C. and E. A. Colburn (Pat. Abs.) 54
—, Molybdenum, Analysis of. H. Westling and C. Anderson 89
—, Process of Extracting Values from, H. Foersterling and A. L. Halvorsen (Pat. Abs.) . 252
Osborne liner. 49
Osterloh, F. L., and Thomas, Jas. F. The Construction and Maintenance of Slime Dams. Discussion 65, 138, 185
Reply to Discussion 218
Overwinding Prevention device, Improvements in. H. Newbery (Pat. Abs.) 228
Oxacetylene Welded Joint in Steel Plate 284
Oxy-acetylene Process and the re-making of Shovels 121
Oxygen Mine Rescue Apparatus, Use and Testing of. 141
Oxygen in Working Cyanide Solutions, The Estimation of. H. A. White 292
Discussion 296

P

Packing Underground at the Ferreira Deep Mine, Systematic, G. Hildick Smith and Paul Selby .. 9
Discussion 22, 39, 71, 103, 147
Palau 154
Palladium Gold Crucibles as Platinum Substitutes. 154
Palmer, G. T.—A Study of the Methods for determining Air Dustiness. . 92
——, L. A.—Salt Manufacture by Solar Evaporation of Sea Water. . 47
Paper-making materials from South Africa . . 92
Papers read during year 288
Parmelee, J. G. Cyaniding Flotation Concentrate. 165
Patent Applications, Abstracts of. 54, 93, 118, 160, 196, 228, 252, 284. 312
Pearce, S. H.—on Mercury. . . 170
Pelouze's method for Estimating Nitrates, Modification of, E. A. Letts and F. W. Rea . . 279
Pepler, D. J. on Electric Furnace Manufacture of Shoes and Dies. . 242
Percussive Tools, Improvements in fluid operated, L. C. Bayles (Pat Abs.) . .. 228
Phosphate Rock, Determination of Phosphoric Acid in. C. C. Semple 156
—— ——, Utilization of. G. A. Roush 160
Phosphates, Calcium, Solubility of, in Citric Acid, A. A. Ramsay 155
—, *Conversion of Insoluble, I. McC. Johnston.* 140
—, Saldanha Bay, A. L. du Toit. 169
Phosphor Tin, R. E. Lee. .. 164
Phosphoric Acid in Phosphate Rock, Determination of. C. C. Semple 156
— Oxide, Some factors influencing the solubility of, in Mixed Fertilisers. E. V. Flack. . 163
Phthisis, Miners', Elimination of. 137
Physical Exercises, Value and Importance of. W. Milligan 227
— Science, Elements of, W. Briggs (*Review*) 27
Pigstyes . 13
—, Details of Construction of. 105
Pilgrims Rest Ore, Notes on Treatment of, Robert Lindsay Discussion 27, 36, 63
Reply to Discussion 99
Pillars, Failure of. 42
Pipe, Life of Cast-iron. 283
— Lines and intermediate tracks 15
Platinized Asbestos, Analysis of. V. N. Ivanov 90
Platinum, New Alloys to replace, F. A. Fahrenwald 157
— Substitutes, Palladium Gold Crucibles as, 154
— Sulphide, New Method of Precipitating, V. N. Ivanov. 90
—, World's Production of Crude 158

PAGE

Pohl, J. J. B.—on the Estimation of Injurious Dust 215
Poisoning, Carbon Monoxide, Y. Henderson. 92
Portier System of Cementation ... 257
Potash, An available source of, E. A. Ashcroft. 247
—— Felspars for fertilizers. ... 127
Powell, A. R., and Schoeller, W. R.—Rapid method of determining Nickel and Cobalt in Ores and Alloys. 114, 161
Power Developing and transmitting device, J. Peterson (Pat. Abs.) . . 91
Precipitation of Gold, Charcoal, H. G. Walton. 191
——, Sodium Sulphide, R. B. Watson. 90
President (G. Hildick Smith)—on Appeal for papers. 56
——, ——, on Assayers' Certificates. 121
——, ——, on Covering Cyanide Dumps. ... 120
——, ——, Departure of. 216
——, ——, on Electric Furnace Manufacture of Shoes and Dies. .. 72, 85
——, ——, on the Estimation of Injurious Dust in Mine Air. .. 206, 211
——, ——, on Fertilizers. ... 128, 130, 132
——, ——, on Joint Meeting with S.A. Inst. of Electrical Engineers ... 55
——, ——, on Logarithmic Calculator. ... 62
——, ——, on Members on Active Service. . 56
——, ——, *Presidential Address.* 56
——, ——, Silicosis in Rats. 137
Price, B.—on Electric Steel-melting Plant ... 86
——, ——, on Joint Meeting. 1
——, ——, on Systematic Packing Underground. 23
Prim, A.—Separation of Antimony and Tin in Hydrochloric Acid Solution ... 223
Proceedings at Ordinary General Meetings :
(Jointly with S.A. Instn. of Engineers)
June 30, 1917 1
September 15, 1917 ... 55
(Jointly with S.A. Institute of Electrical Engineers)
September 29, 1917 . 72
October 20, 1917 . 95
November 17, 1917 ... 119
February 16, 1918 .. 173
March 16, 1918 .. 197
April 20, 1918 229
May 18, 1918 253
(22nd Annual Meeting)
June 22, 1918 .. . 285
Pumps and Compressors, Improvements in, J. Zwicky (Pat. Abs.) 118
——, *Diaphragm, Application of Metallurgical Work.* *L. B. Eames.* 95
——, Rotary, Improvements in, A. E. Shiner (Pat. Abs.)... 252
Pyrites in the United States 305
Pyrophosphate, Magnesium, The Colour of, D Baraleff. .. 90

R

Ramsay, A. A.—Solubility of Calcium Phosphates in Citric Acid .. 155
Rand, Mining Problems on the, H. Foster Bain. 167, 192
Rarer Elements, Introduction to the, P. E. Browning (*Review*) .. 112, 196
Rats, Silicosis in, in a Witwatersrand Mine. *J. Pratt Johnson.* *Discussion* 135, 211
Reply to Discussion ... 209
Reciprocating Implements, Improvements in Power-driven G. Constantinesco and W. Haddon (Pat. Abs.) . 160
Reclamation of Ore. 15
Red Cross Mission to Palestine, American. ... 229
—— Society, South African,... .. 288
Refining, Electrolytic Copper, Impurities in, L. Addicks. 158
Refractory Properties of Silica. H. le Chatelier and B. Bogitch. . 156
Rescue Apparatus, Oxygen Mine, Use and Testing of, ... 144
Research Work on Mines. 56
Respirators for Mine Dust. 137
Reviews. 27, 46, 87, 93, 112, 196
Rice, G.—Mechanical Ventilation of Metal Mines. 224
Rickard, T. H.—Grinding Ore for Flotation 280
Robinson, D. R.—Logarithmic Calculator 60
Discussion 186
Reply to Discussion 219
Rock Crushing, Investigation on, ... 88
—— Drill Cradles, Improvements in, Ingersoll Rand Co. (Pat. Abs.) 284
—— Drilling Apparatus, Improvements in, S. Rudberg (Pat. Abs.) .. 118
—— Drills, Comparative values of, ... 309
—— ——, Improvements in automatically fed, J. H. Veasey (Pat. Abs.) 94
Rothschild, S.—Determination of Nickel in presence of Zinc and Iron. .. 48
Rouillard, A. P.—Mule Haulage Underground at the Durban Roodepoort Deep Mine 31
Discussion 139
Roush, G. A.—Utilization of Phosphate Rock 160
Rubber, Synthetic, ... 190
Rusden, H.—on the Estimation of Oxygen in Working Cyanide Solutions. . 293
——, ——, on Mercury. 173

S

Sacher, J. F.—The Chemical Evaluation of Chromic Acids and Alkali Dichromates. 113
——, ——, Soap as an Indicator in Volumetric Analysis. 113
Saldanha Bay Phosphates. Dr. A. L. du Toit. 169
Salt Manufacture by Solar Evaporation of Sea Water. L. A. Palmer. ... 47
Sandfilling. 5, 42
—— *of Mines, Further Notes on,* *C. H. Greathead* 236
Discussion 240
Schoeller, W. R., and Powell, A. R.—Rapid method of determining Nickel and Cobalt in Ores and Alloys. 114, 161
Sea Water, Salt manufacture by Solar Evaporation of, L. A. Palmer. ... 47
Selby, Paul, and Smith, G. Hildick.—Systematic Packing Underground at the Ferreira Deep Mine. ... 9
Discussion 22, 39, 71, 103, 147
Semple, C. C.—Determination of Phosphoric Acid in Phosphate Rock. 156

PAGE

Separating Substances, Improvements in Apparatus for, of different specific gravities. J. M. Draper (Pat. Abs.) .. 284
Shaft Gates, Improvements in. J. Whitehouse, J. P. Nelson and F. Robinson (Pat. Abs.) . 54
— Pillar, *Notes on the Removal of a Vertical,* *J. Chilton.* ... 297
Discussion . 300
Shakudo. ... 157
Shaw's Valves for Slime Circuits. 116
Shibuichi. 157
Shoes and Dies at Simmer and Jack. 251
— —, *Electric Furnace, Manufacture of, on the Witwatersrand.* *G. H. Stanley* 72
Discussion 85, 139, 186, 240
Reply to Discussion ... 268
Shovels, Remaking of, .. 121
Silica Bricks and some new uses for them. W. Gray . . 92
—, Fused. F. Bottomley. . 154
—, Refractory Properties of. H. le Chatelier and B. Bogitch. . 156
Silicosis in Rats in a Witwatersrand Mine. *J. Pratt Johnson.* *Discussion* 135, 211
Reply to Discussion 201
Sisal Hemp 159
Skinner, Harry Ross, on Cementation Process 267
Slime Circuits, Valves for. T. B. Stevens. 116
— *Dams, The Construction and Maintenance of,* *J. E. Thomas and E. L. Osterloh.* *Discussion* 65, 138, 185
Reply to Discussion . . 218
— Tables, Improvements in Concentrating or. M. H. Baker. . 252
— Thickening Vats, Determining of the Capacities of. R. T. Mishler. 115
Smelting, Electric, of Titaniferous Iron Ores. A. Stansfield. ... 144
Smidt, S. de, on Systematic Packing Underground 25
Smith, G. Hildick, for remarks by see under "President."
—, —, *and Selby, Paul—Systematic Packing Underground at the Ferreira Deep Mine.* 9
Discussion 22, 39, 71, 103, 147
Smyth, H. Warington, on Fertilizers and the Work of the Scientific and Technical Committee 130
—, —, The Industrial Resources of South Africa . 28
Soap as an Indicator in Volumetric Analysis. J. F. Sacher. 113
Soda Carbonate 220, 222, 233
Sodium and Calcium Bicarbonates in Boiler Feed, Determination of. H. Monhaupt. 47
— *Manganate, The manufacture of Crude, for use on the mines.* *F. Wartenweiler* 161
Discussion 183, 212, 303
— Sulphide Precipitation. R. R. Watson. . 90, 142
Solar Evaporation of Sea Water, Salt Manufacture by, L. A. Palmer 17
Solid matters from Fluids, or Fluids from Fluids, Apparatus for separating. F. E. Moss (Pat. Abs.) 284
South Africa, Industrial Resources of, H. W. Smyth. . .. 28
Specific Gravities, Improvements in Apparatus for separating substances of different, J. M. Draper (Pat. Abs.) . 228
Stanley, G. H., on Assay Supplies . 235
—, —, on Cementation Process 267
—, —, *Electric Furnace Manufacture of Shoes and Dies on the Witwatersrand* 72
Discussion 85, 139, 186, 240
Reply to Discussion 268
—, —, on Fertilizers ... 132
Stansfield, A.—Electric Smelting of Titaniferous Iron Ores. ... 50, 144, 157
Stuart, F. A., and Vaughan, J. E.—Some Notes on Explosions of Fire Damp and Occurrences of Gob Fires in Natal. *Discussion* 101
Reply to Discussion ... 216
Steel, Determination of Chromium and Vanadium in. H. L. Hamner .. 190
—, Electric, .. 144
— *Melting Plant, Electric,* *W. Buchanan.* . . 83
Discussion .. 85, 139, 186, 240
— Plates, Oxyacetylene Welded Joint in. . . 281
Stellite 143
Stems, Battery ... 255
Stevens, T. B.—Valves for Slime Circuits .. 116
Stope Measurement at the Messina Mine. W. Whyte. . 50
Students, New, .. 55
Stulls, ... 43
Sulphide on Cement, Effect of . 283
— Precipitation Methods. 90
Sulphuric Acid, Titration of, Notes in regard to, C. R. Gyzander. ... 89
Support of the Underground Workings in the Mines of the Rand, Notes on the, *P. Cazalet* .. 2
Discussion 23, 39, 71, 103, 117
Supports, Mine-roof, Resistance of Artificial. W. Griffith 226
Sweeney, O. R., and Withrow, J. R.—Chemical Examination of Natural Brines 155
Sylvite and Carnallite, Iodine Content of Strassfurt. L. W. Winkler 113

T

Tambookie Grass. 92
Tar, Coal, Continuous Distillation of. 307
Thomas, A., on Mercury 174
—, J. E., on the Estimation of Oxygen in Working Cyanide Solutions. 295
—, —, *and Osterloh, E. A.—The Construction and Maintenance of Slime Dams.* *Discussion* 65, 138, 185
Reply to Discussion 218
Tholund, J., on a Logarithmic Calculator 186
—, —, on Support of Underground Workings and Systematic Packing 103
Thymolphthalein and Naphtholphthalein, New Applications of. *Dr. James Moir* *Reply to Discussion* 62
Timber Props 43
—, Round, The use of, for Props, etc. . 5
Timbering, Square Set Method of, 5

PAGE

Tin and Antimony, Separation of, in Hydrochloric Acid Solution. A. Prim 223
— Concentrate. Wet Assay of. H. W. Hutchin 48
—. Phosphor, R. E. Lee ... 164
— Plate, Detinning and Analysis of, G. W. Heise and A. Clemente ... 153
Titaniferous Ores of Iron. The Smelting of, A. Stansfield and W. A. Wissler ... 50
Titanium Ores, Distribution and Uses of. .. 165
Toit. Dr. A. L. du.—Saldanha Bay Phosphates 169
Toombs, Chris.—Assay Economics 220
Discussion ... 233, 253
Tregaskis. S. T.—on the Furnace as an adjunct to the Smithy 291
Trommel Feeder Chute 180
Trucks, Improvements in loading and unloading. J. Glynn (Pat. Abs.) 160
—, —, in means for automatically tipping. W. H. Johnston and C. E. Francis (Pat. Abs.) 93
Tube-mill Practice, A. W. Allen ... 48
— Milling, A. del Mar (*Review*) ... 93
— Mills, Improvements in the linings of, W. J. McQueen (Pat. Abs.) ... 160
Tungsten, Determination of, H. W. Hutchin 223

U

Underground Stables ... 32
— *Workings in the Mines of the Rand, Notes on the Support of the, P. Cazalet* 2
Discussion 23, 39, 71, 103, 147

V

Vacuum Ejector Apparatus, Improvements in. A. E. L. Scanes (Pat. Abs.) ... 228
Valve, An Improved, for Compressed Air. A. Purser and G. D. Hook (Pat. Abs.) 196
Valves for Slime Circuits. T. B. Stevens 116
Vanadium and Chromium in Steel. Determination of, H. L. Hamner ... 190
Vats, Displacement. W. S. Weeks ... 310
—, Slime Thickening, Determining of the Capacities of, R. T. Mishler ... 115
Vaughan, J. E., and Steart, F. A.—Some Notes on Explosions of Fire Damp and Occurrences of Gob Fires in Natal. Discussion 101
Reply to Discussion ... 216
Ventilation of Metal Mines, Mechanical, G. Rice 224
— on Witwatersrand Mines 27
Ventilators, Improvements in, C. Wright (Pat. Abs.) 228
Vivane 159

W

Wallace and Tiernan Pump 92
Walton, A. J.—on Support of Underground Workings and Systematic Packing . 147
—, H. G.—Charcoal Precipitation of Gold 191

PAGE

Ward. H.—on Mercury .. 198
Wartenweiler. F.—Gold Absorption by Copper Amalgamation Plates .. 246
—, —, *The Manufacture of Crude Sodium Manganate for use on the Mines* 162
Discussion ... 183, 242, 303
—, —, on Mercury 177
Waste Packing, ... 43
— Rock. Packing or stowage of 5
Water, Notes on an Underground Spring of, containing Manganese and Lithium. John Watson 181
Discussion 183
Watson. F. W.—on Assay Supplies 234
—, —, on Assayers' Certificates 120
—, —, on Fertilizers 132
—, —, on the Manufacture of Crude Sodium Manganate .. 183
—, *John.—Assay Requisites* 222
Discussion 233, 253
—, —, on Assayers' Certificates 120
—, —, on Fertilizers 183
—, —, on an Interesting Pebble 181, 253
—, —, on the Manufacture of Crude Sodium Manganate 242
—, —, on Mercury 178
—, —, on a new method of determining Copper 135, 270
—, —, *Notes on an Underground Spring of Water, containing Manganese and Lithium* 181
Discussion 183
—, R. B.—Sodium Sulphide Precipitation 90, 142
Wattle Bark Industry of Natal 144
Weeks. W. S.—Displacement Vats 310
Weinbren. M.—on the Estimation of Injurious Dust in Mine Air ... 276
Westling. H., and Anderson. C.—Analysis of Molybdenum Ores 89
Weston. E. M.—on the Cementation Process 305
—, —, on the Construction and Maintenance of Slime Dams 70
—, —, on Electric Furnace Manufacture of Shoes and Dies 241
—, —, on the Estimation of Injurious Dust in Mine Air 273, 304
—, —, on the Furnace as an adjunct to the Smithy 256
—, —, on Mercury 197 232
—, —, on Mule Haulage Underground.. 139
—, —, on the Natal Coalfields . 64
—, —, on the Re-making of Shovels . 121
—, —, on the Removal of a Vertical Shaft Pillar 300
—, —, on Sandfilling of Mines . 240
—, —, on Silicosis in Rats 135
—, —, on Support of Underground Workings and Systematic Packing ... 71
Whitby. A.—on American Red Cross Mission 229
—, —, on Assay Supplies 234
—, —, on Assayers' Certificates .. 120
—, —, on Mercury 232
—, —, on Treatment of Pilgrims Rest Ore 63
White, H. A.—on Assay Supplies 233
—, —, on Assayers' Certificates ... 121
—, —, on Cementation Process ... 268

PAGE

White, H. A.—on Congratulations to Sir R. N. Kotzé 255
——, ——, on Departure of President 216
——, ——, on Electric Furnace Manufacture of Shoes and Dies .. . 187
—— ——, *The Estimation of Oxygen in Working Cyanide Solutions* 292
Discussion ... 296
—— ——, on Fertilizers . .. 129
——, ——, on Mercury 175
——, ——, on Cyanide and Zinc Consumption 111
——, ——, on Treatment of Pilgrims Rest Ore .. . 63
——, ——, on an Underground Spring . 183
Cinos, Ore Treatment at, J. G. Kirchen 307
Whitehouse, J.—on the Estimation of Injurious Dust in Mine Air . 244
Whyte, W.—Stope Measurement at the Messina Mine 50
Wilkinson, J. A.—on American Red Cross Mission . 231
——, ——, on Assay Supplies .. 235
Winkler, L. W.—Iodine Content of Stassfurt Sylvite and Carnallite ... 113
Wire Ropes, Faggotting of. .. 255
Withrow, J. R.—Possible Adulteration of Nitric Acid 157
Witt, J. C.—Testing of Galvanised Iron 153
Witwatersrand Mines, Ventilation on. 27

PAGE

Wood Preservation, Practical, W. E. Hoyt . 281
Woodburn, J. A.—on Electric Furnace Manufacture of Shoes and Dies 86, 130
——, ——, on the Estimation of Injurious Dust . . 212
——, ——, on Support of Underground Workings and Systematic Packing 105

Z

Zinc Consumption, A method for further reducing Cyanide and, P. C. H. Cooke . . . 33
Discussion . 111, 185
——, Electrolytic 143
Gold Slime Calcining . 174
—— —— ——, Improvements in Treatment of, C. E. Meyer (Pat. Abs 228
—— —— ——, Recovery of Mercury from 175
——, New method of Precipitating Gold from Cyanide Solutions by, H. R. Conklin . .. 18

Y

Young, R. B.—The alteration of Dolomite near Potgietersrust 283

TN
1
S66
v.17-18
~~Physical &~~
~~Applied Sci.~~
~~Serials~~

Engineering

South African Institute of
Mining and Metallurgy
Journal

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE